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Edited by

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High Definition Archaeology: Threads Through the Past
Edited by John A. J. Gowlett

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Cover Moose or elk: common in the faunal lists of early Holocene and late Pleistocene sites. Two specimens of elk were found in the upper levels at Stellmoor. Illustration by David Pratt.

Future Issues

Vol. 29 No. 3 *Intimate Relations*, ed. Y. M. Publication in February 1998.

Vol. 30 No. 1 *The Past in the Past: The Reuse of Ancient Monuments*, ed. R.B. Publication in June 1998.

Vol. 30 No. 2 *Population and Demography** ed. S. S. Submission by 1 February 1998 for publication in October 1998. Questions of population and demography tended to disappear from the archaeological agenda following the mid-1970s critiques of explanations based on population pressure and the questioning of the methods of palaeodemographic reconstruction from cemeteries. In the last few years, however, it has again become apparent that a knowledge of the demographic aspect of human groups is essential to the study of many past processes. Papers are welcomed on all aspects of population and demography in archaeology and related subjects (such as anthropological genetics), including colonization processes, interactions of population and environmental change, population and social change, and methods and results of palaeodemographic reconstruction.

Vol. 31 No. 1 *Food Technology in its Social Context: Production, Processing and Storage*,* ed. K. T. Submission by 1 October 1998 for publication in June 1999. Food production, processing and storage in past societies have usually been treated from technological or environmental-cum-ecological perspectives, although the social dimensions of these phenomena, in terms of political and economic control, have sometimes been explored for more complex societies, such as those of ancient Mesopotamia. Papers are invited on any aspect of the above theme, for any type of past social or subsistence system in any part of the world. It is anticipated that published papers will include theoretical treatments as well as specific archaeological case studies or methodological/analytical approaches. Please contact the editor as soon as possible with ideas. suggestions and offers (E-mail address: k.thomas@ucl.ac.uk).

Editorial policy is to invite a number of articles which may form the core of each issue; others are encouraged to submit material relevant to the theme for consideration. The issues marked with an asterisk in the above list are still in the planning stage, and contributions are invited. Intending contributors should note, however, that each issue is made up six months before publication date and that the editor in charge normally begins planning about eighteen months before publication date.

For further details on presentation of manuscripts, see the Notes to Contributors at the end of this issue.

It is not current editorial policy to publish book reviews as a regular feature of the journal. Review articles will cover recent publications in particular fields, and lists of books received will be published from time to time.

Theme titles of past issues of *World Archaeology*. These are all available from Routledge Journals, price £20.00/$35.00

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High definition archaeology: threads through the past

Editor: J.A.J. Gowlett

This issue seeks to bring together case studies of archaeological sites or projects where analyses of high resolution data have traced relationships or decision paths that we could not have seen with simpler techniques of recording and analysis.

Archaeology now collects data in much greater resolution than ever before, but this presents difficulties and dangers as well as advantages. The underlying idea for this issue came from an observation made thirty years ago by J.D. Clark, one of the pioneers of high resolution work: archaeologists would be 'unable to derive any significant benefit from such new data until they have considerably improved their techniques of analysis of the cultural material' (Clark 1967: 414). By now a generation's advances in practice and theory might be expected to allow significantly greater rewards or pay-offs to be extracted from investment in datasets of finds, contexts and co-ordinates that are sometimes colossal. The aim of the issue was to find a set of case studies where people have successfully applied analyses at high resolution, thus picking out and giving definition to links or past decision tracks (threads or even something like the 'superstrings' of physics) that we simply could not have seen with earlier techniques.

Approaches of high resolution are available to all periods, though with different emphases. The Palaeolithic traditionally aims to squeeze its data hard, and relies heavily on stone artefacts and bones as tracers of operational chains in sites which were often of short duration. Later periods seek behavioural resolution in settlements which were so longstanding that most behaviour was swept away by the inhabitants themselves. The issue includes examples from different perspectives reflecting the importance of household archaeology, community structure, and industry.

Reference

Clark, J. D. 1967. Introduction to Part III: B Sub-Saharan Africa. In *Background to Evolution in Africa* (eds W. W. Bishop and J. D. Clark). Chicago: University of Chicago Press, pp. 413–16.

High definition archaeology: ideas and evaluation

J.A.J. Gowlett

Archaeology has a conundrum: day by day it accumulates data on a vast scale; but when we seek to tackle any specific problem, or even to present a representative picture, there are usually vast gaps in our evidence. Researchers who seek to fill them find that the very advances in technique which help us to understand the past add up to a massive burden. To improve on old work we need greater resolution, but that means achieving on a far smaller scale or at far greater expense of time and money; and, in either case, with enormous investment in data.

Concerns were summarized by Chris Chippindale in a recent *Antiquity*:

> Some appalling number of archaeological objects are being dug up. . . . Debitage (how many kilos?), coarse-ware (how many tonnes?), animal bones (ditto?), building material (how many tens of tonnes?) is dumped or lumbered into museum stores whose curators wish the stuff had stayed in, or gone back into, the ground.
>
> (Chippindale 1996: 739)

Small wonder that Clive Gamble, surveying the Palaeolithic, was led to stress that we need archaeological theory, rather than more facts – especially, new ways of looking at the insights that can be gained from related disciplines (Gamble 1996: xxiii). Even thirty years ago J. D. Clark noted that techniques of analysis had not kept up with techniques of recovery (Clark 1967: 414), calling then for an ethnoarchaeological approach, as well as a better-integrated palaeoecology and other analytical improvements. But new approaches and new data need not be mutually exclusive: Clark's own practice has been to forge on with fieldwork, linking theory and practice interactively.

We do require new data; and the problem surely lies where evidence is brought out mindlessly, as a matter of form, rather than thoughtfully so as to address research questions. Admittedly, there is a law of diminishing returns for increased effort, and it is hard to judge where it sets in. The huge mass of material is often a necessary evil if we are to gain certain vital information. But to understand behaviour, the dynamics of past assemblages, is a matter of understanding relationships between artefact and artefacts, between artefacts and contexts. Finds may fill warehouses, but there is virtually no mass in relationships. For that reason it seems justifiable to look on the potential of higher resolution almost entirely positively, although high costs will sometimes make it controversial. With

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risks of unjustified effort, of spurious precision, or of focusing on the trivial and ephemeral, it is necessary to ask critical questions.

Critical analysis

Is there any such thing as high resolution archaeology? One can select out any kind of archaeology as a dimension (as *World Archaeology* themes show), but if behaviour is our interest, no one dimension will be uncorrelated with others. High resolution can be coupled with geographical approaches, settlement archaeology, quantitative approaches, sourcing, palaeoecology, to name just a few.

Nevertheless, I would argue that it has a reality: in fieldwork we lift artefacts from sediments, and the ancient relationships between these finds and contexts are more or less recoverable depending upon our approach. It may be current fashion to talk of 'dynamics of past behaviour', but that has the solid meaning that we wish to trace what people did: we are looking at human navigation through space and time, as shown by individual events and interactions.

The very essence of perception in an intelligent system is that it must filter out the excessive inputs of an overfull world of stimuli (Broadbent 1987). Archaeology has to do this when it distills final interpretation from great masses of data. Here artefacts can offer an analogy for other archaeological research: we used to study them by eye; then with measurements to provide greater objectivity. Now computers and scanners allow a total 3D record at high resolution. In display, the eye can appreciate these virtual artefacts – it simplifies and interprets naturally – but for actual analysis, we have to select the essential, and again drop the great mass of the data (cf. Crompton 1997). In everyday social life people do this with reasonable success. In our intuitive navigation of society we can live in a city of a million people, and be concerned directly with less than 500, nevertheless having some impression of the totality. Human beings can handle restricted numbers of relationships, but even these require a great deal of mental processing (cf. Dunbar 1996). Probably most *archaeological* reconstructions of society are based on our intuitive processes, in spite of theory.

But this raises the question of whether we actually need great detail in archaeological investigation. Perhaps we can jump directly from generalized evidence to generalized interpretation, referring just to the handbook of middle range theory when necessary. Perhaps we can learn little from the individual who sat here and knapped, or the other who there dropped a pot. The actions best preserved at high resolution may be the trivial, ephemeral or abnormal. Stone tools, for example, are wonderful markers (Isaac's 'visiting cards': 1981), but stem from sporadic activities, perhaps practised only by some members of a community.

I would argue that this view is too negative. Individuals may represent their societies in what they do. Their activities may add up to patterns, which can be understood only through perceiving their individual elements. Related actions do indeed sometimes represent threads through the past. They help us to see what was intended, what casual; to distinguish events that happened in moments from those of palimpsests. And they help at such a basic level as enabling us to check stratigraphic integrity (e.g. Villa 1983).

Archaeology remains essentially investigation of the past from its material remains. We still seek greater truth – not through moreness, but through analysis, which must distil vital information from the redundant evidence.

Landmarks of resolution

High definition in archaeology can be found over a long period, at least from the nineteenth century. It was encouraged sometimes by exceptional preservation, because the damage done is more obvious if care is not taken. This was so at Pompeii where appropriate methods were developed in the nineteenth century. At a formative time, when arguments about human antiquity were being fought out (Lyell 1863), the Swiss lake villages particularly stimulated careful work (Fig. 1). Keller (1878: in translation) was able to articulate views that modern archaeologists often express:

> By systematically excavating the settlements . . . . we not only obtain more correct information as to the construction of the pile work, the form, mode of erection, and size of the huts, but we even get a glance into the interior. Wonderful to relate, we can walk over the very flooring of these dwellings, abandoned thousands of years ago. We see before us their hearths and their various household utensils. We obtain information as to the industrial habits of the people, the nature of their food, and the mode in which they were clothed.

Some of these structures were carefully recorded, and at least in passing the positions of artefacts. But then there was no science of proxemics or ekistics, nor even of central place. The artefacts clearly provided the predominant interest and are treated in chapter after chapter, whereas spatial arrangements are hardly discussed.

As archaeology re-emerged after the First World War, a geographical preoccupation was now apparent. It was central to the approach of Crawford (1921), but he remarked that geographical and anthropological concerns were shown far more prominently in German, French and Austrian journals than British. Becker (1985) echoes this, remarking that it is now too easy to overlook that Kossina's 'siedlungs-archäologische' methods were 'epoch-making for the whole profession'. These were early analyses requiring resolution – at least that of a distribution map – but in his methods, Crawford expresses the bias created by the lack of absolute dating: one had a framework of artefacts, structured by association and stratification: relationships of artefacts in time excessively outweighed relationships on the ground, or short timescales within site.

This contrasts with the already totally systematic approach to fieldwork applied by some continental European workers, including Alfred Rust in the investigation of lateglacial sites in North Germany. Rust had a deep belief that settlements could be found *in situ*. In his excavations of the lateglacial sites of Meiendorf and Stellmoor he was frustrated to find remarkable organic preservation, but secondary context: the sites had been placed on channel banks, now eroded, and he was finding toss zones where refuse had been thrown into the water (Rust 1937, 1943; for an English summary see Clark 1975). Rust remained resolved to seek the actual camp sites. In 1936 he settled upon the Pinnberg, a low mound protruding from the Ahrensberg tunnel-valley. 1938 saw the main

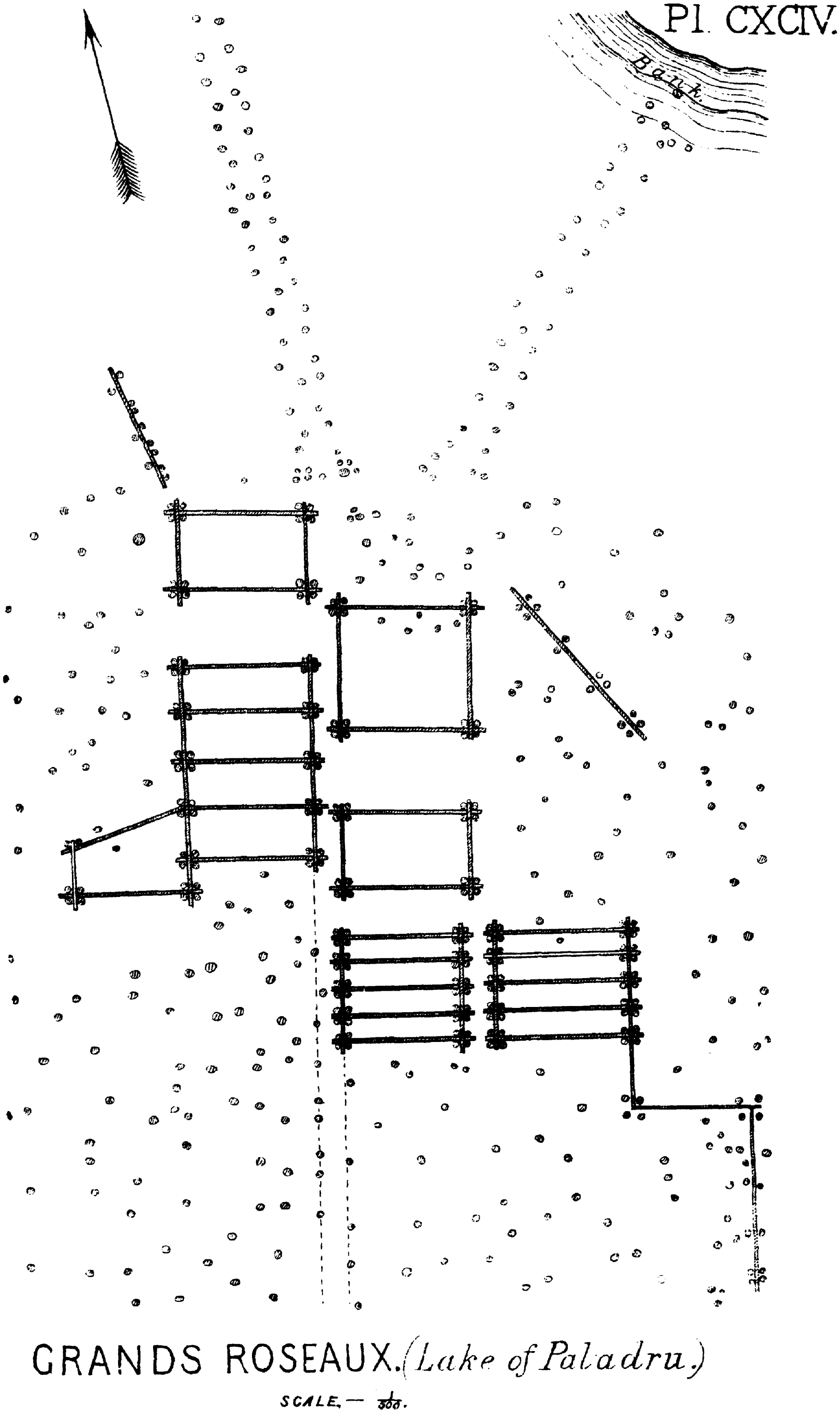

Figure 1 Highly detailed planning of finds in one of the Swiss lake villages (after Keller 1878).

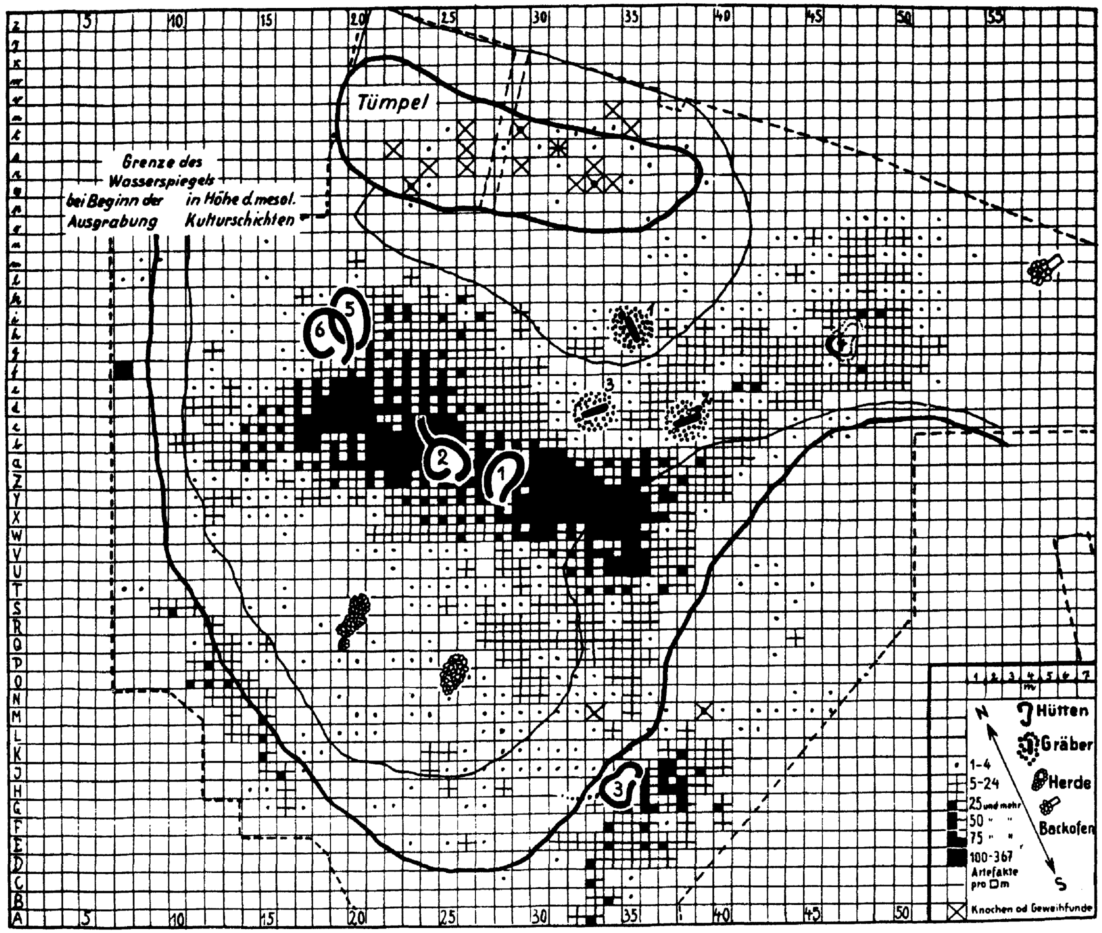

Abb. 4 Lageplan der Kulturreste auf dem Vorland des Pinnberges. Gestrichelte Linie = Begrenzung der Ausgrabung

Figure 2 The Mesolithic settlement at the Pinnberg as excavated in 1938: Alfred Rust's plan of the area excavations (Hütten = huts; Gräber = graves; Herde = hearths; Backofen = oven). Artefacts were shown in density per square metre, and bone/antler finds by oblique crosses. After Rust (1958), reproduced courtesy of K. Wachholtz Verlag.

season of excavations (Fig. 2). Because of the war, the final publication came only much later (Rust 1958), but it shows well the practice of total excavation, continuous surfaces, and precise recording and photography that was Rust's hallmark from the 1930s. This was shared by other German workers, for example Bersu (1940), and has been continued in a great tradition of open site archaeology extending across central Europe to Russia. In this, German stone age sites have remained strikingly represented (Bosinski 1979; Conard 1992; Conard et al. 1995; Street 1986; Thieme 1996).

Elsewhere, ideas of focusing on stratigraphic columns, at the expense of spatial extent and of contemporaneous variability, were commonly an impediment. Even first-rate field-workers like Sir Mortimer Wheeler, whose field methods concentrated on linking plans and sections, often used grand sections in a way that was essentially illustrative. In a technical manual (one of the first of its kind) Leroi-Gourhan (1950) mocks gently those who 'make an initial trench, and then scrape at the layers as if working on a quarry front'. This remains the search for curious objects, whereas 'the aim of prehistory is to learn how people used to live: people did not live like flies stuck to a vertical wall'.

Leroi-Gourhan's first great principle was that one dug horizontally, by 'décapage' (Fig. 3). This did not mean that you denude a hectare site in centimetre layers. The idea was to excavate several square metres at a time, keeping contact with a section on at least two sides. This approach was followed first at Arcy-sur-Cure and then at Pincevent. The work inspired at the cave complex of Arcy is perhaps less well known, but even now continues to produce results (Schmider et al. 1995). Pincevent has recently celebrated thirty years of excavations, and a vast area has been uncovered in investigation at the highest resolution (Figs 4 and 5). The many categories of remains – flint, bone and antler, and hearth stones – have all been studied separately, and the relationships between pieces traced

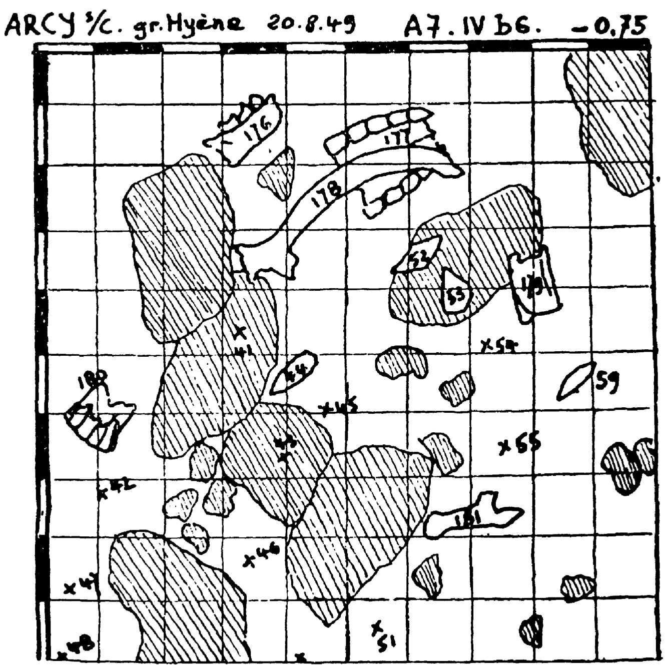

Figure 3 Leroi-Gourhan's mode of recording the finds in a single metre square, as practised at Arcy-sur-Cure in 1949 (from Leroi-Gourhan's handbook of 1950), reproduced courtesy of A. & J. Picard and Co.

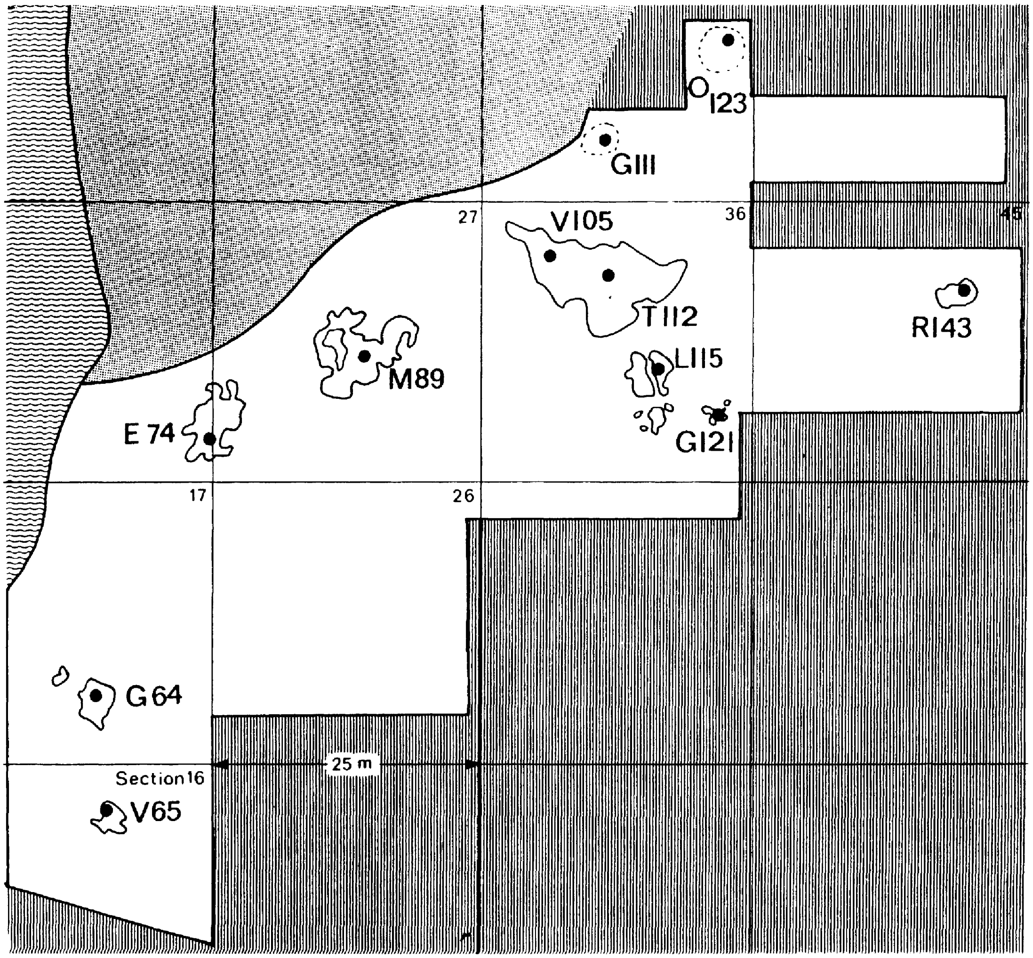

Figure 4 The area of Pincevent level IV2 which had been excavated up to the mid-1980s, showing ten occupation units centred around hearths. Refitting material has demonstrated these to be contemporaneous. After Julien et al. (1987).

(Leroi-Gourhan and Brézillon 1972). A major element was the tracing of 'operational chains', a fundamental concept in Leroi-Gourhan's interpretation of social behaviour, and now widely developed in French prehistory (Boëda et al. 1990).

Another great tradition of Palaeolithic open site archaeology had begun in East Africa, probably inspired by Mary Leakey's early experience in Britain and France. At any rate, Desmond Clark (1990) is quite clear that it was Mary Leakey's early work at Olorgesailie in the 1940s which inspired a 'living floor' tradition in African archaeology. His own early work at the great Acheulean open sites of Kalambo Falls paved the way for other comparable research at Isimila, and again at Olorgesailie itself (Howell and Clark 1963; Howell et al. 1962; Isaac 1977). The 'living floor' approach was most rewarding at Kalambo, where hand-axes and cleavers were found in conjunction with burnt wood and plant remains (Clark 1969).

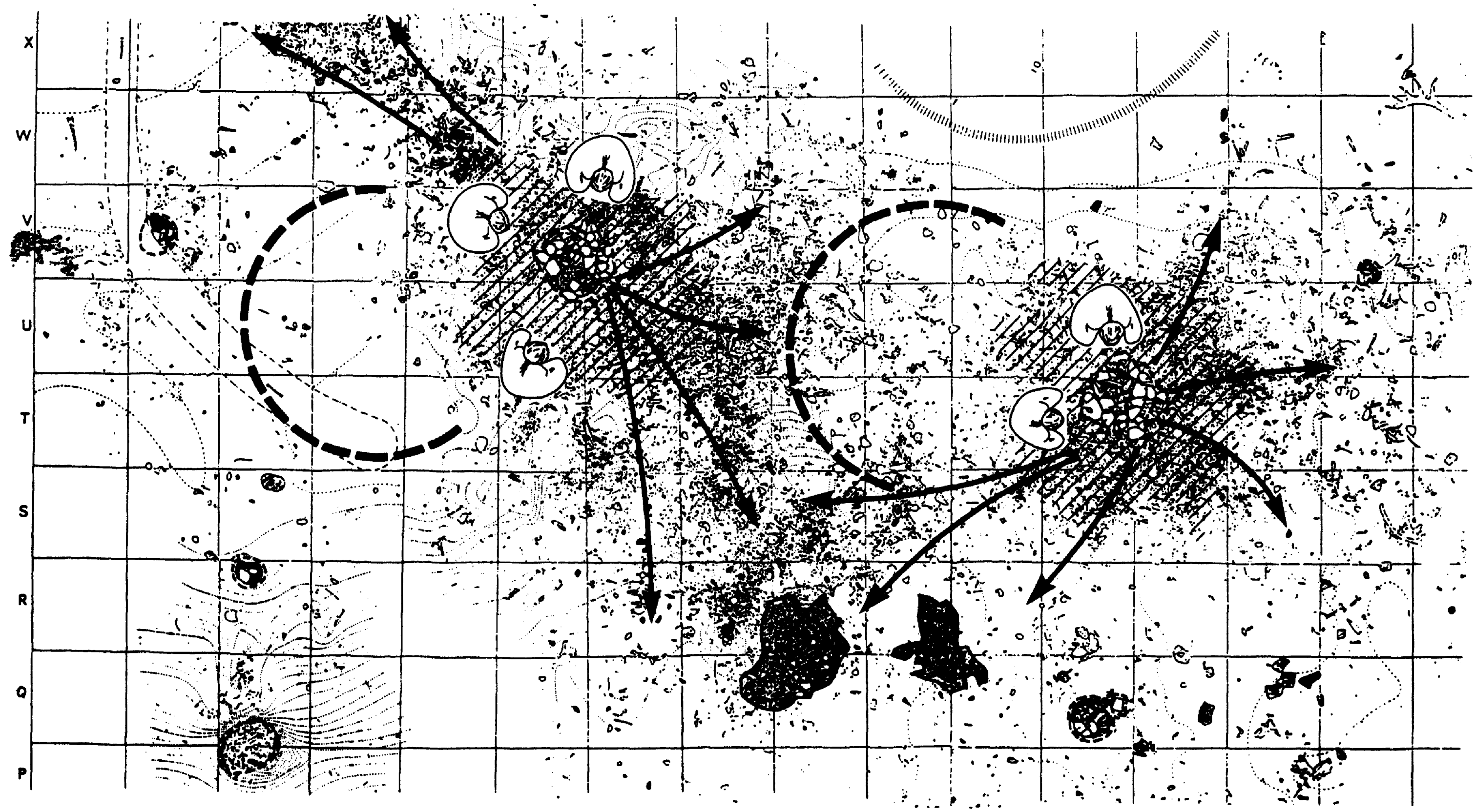

Figure 5 Pincevent: one possible interpretation of the distribution in the famous Section 36 (after Julien et al. 1987). Arrows indicate documented movements of material away from the hearth areas. This interpretation invoked more open huts/tents than postulated by Leroi-Gourhan.

Settlement archaeology

The search for resolution has never been restricted to the Palaeolithic. Most settlement archaeology, however, presents a much greater variety of scale than that of hunter-gatherer campsites (Fletcher 1986). Hugeness of scale militates against concentration of detail, which is easier to record than to use systematically. Again, careful analysis is required to extract, for example, sociological data as at Pompeii (Raper 1977; Laurence 1994), or details of industrial practices as at Harappa (Kenoyer 1997).

Those dealing with later periods and larger sites may need to consider all the levels of household, community organization, cities and regional structure. Household detail has increasingly been perceived as important, partly because it points towards the ordinary side of life. Willey, well known for his approach to settlement archaeology, also promoted household studies. Rathje (1983: 33) was disappointed that his household approach had not been taken up more widely. Some reasons were found by Tourtellot (1983: 37): archaeology had an interest in contemporaneous activity sets, numbers of families, and status variables; but there was a concern that quantities of artefacts found around settlements might correspond more to length of occupation than any other variable.

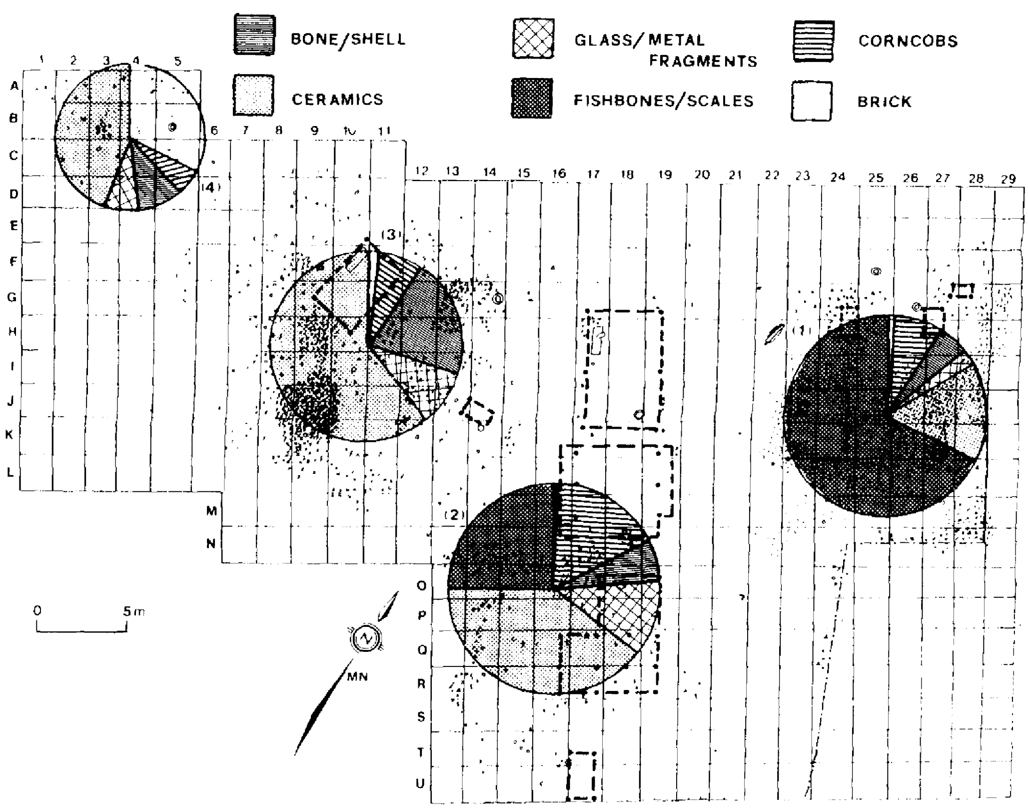

Figure 6 Ethnoarchaeological analysis: Siegel and Roe summarized the 'systemic context' of a modern Shipibo site through a cluster analysis, presenting the material in each cluster through a pie-diagram (Siegel and Roe 1986).

Another view of the likely biases was highlighted by Robbins (1973) in a classic *World Archaeology* paper, which is based on an ethnoarchaeological study of Turkana settlements in north-west Kenya. When Turkana settlements were abandoned, most artefacts were removed; those that remained were largely broken and perishable, and included few Turkana 'type artefacts'; worse, LSA microliths were on the ground, and a future archaeologist might easily link them with the recent settlement. This suggests that at the micro-level settlement archaeology can proceed only through precise studies which maximize the details of evidence, for example through studies of soil micromorphology (Matthews et al. 1997), or ethnoarchaeological insights (e.g. Gould 1980; Siegel and Roe 1986; Fig. 6). Up the size scale, social considerations and models become more dominant (e.g. Fletcher 1977; Hayden 1997; Bintliff 1997).

Quantitative approaches and spatial archaeology

A search for greater objectivity in treating data has led to quantitative approaches, at first adopted gradually over a long period. Clark and Stafford (1982) show graphically how these took off rapidly from 1960 as computers became available. Statistical approaches can be used for abbreviating data, or for exploring it. Both can help pattern to become apparent in a two-dimensional plan. In archaeological recording computers emphasized the value of the single point find, defined by co-ordinates, rather than the quadrat used to assess find density (though cell frequencies plainly retained a value: Fig.1; Johnson 1984; Fig. 7). Quantification was also an indispensable part of the New Archaeology, especially as represented by David Clarke, or Lewis Binford. It was inspired in part by

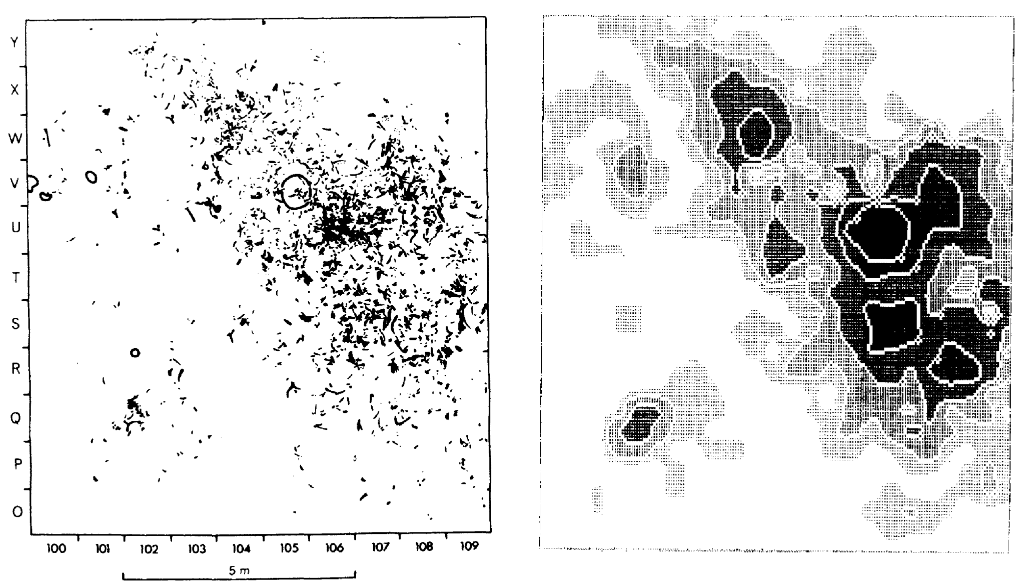

Figure 7 Pincevent: faunal remains on section 36:V105. Left – as plotted by Leroi-Gourhan and Brézillon (1972); right – in a cell frequency analysis generated by Johnson (1984), reproduced by permission of Cambridge University Press.

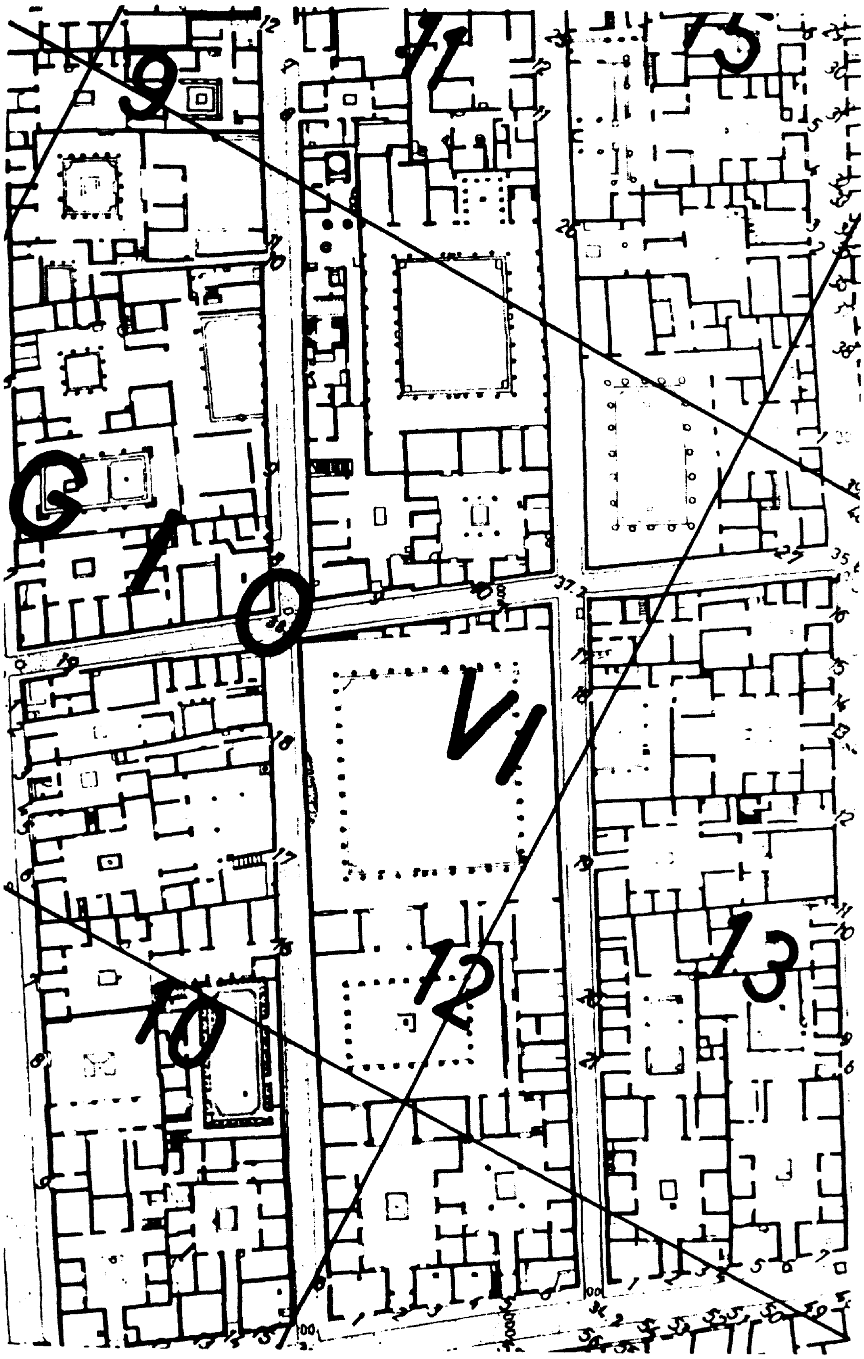

Figure 8 Pompeii: Raper (1977) used H. Eschebach's map as the basis of a land-use analysis which could produce usable results from the high resolution evidence.

geography, this time the new geography, with its approaches to spatial analysis (e.g. Chorley and Haggett 1967). Spatial archaeology seemed to provide integration, since similar techniques could be applied at a number of scales. These included nearest neighbour analysis, dimensional analysis of variance, or Hodder and Okell's coefficient of association (Hodder and Orton 1976; Hodder 1978; papers in Hietala 1984).

The rationale underlying spatial archaeology was that archaeological information lay latent in spatial relationships. In Clarke's view the sociological, economic or ecological had remained the dominant consideration in most studies: the spatial remained secondary (Clarke 1977). Examination of the studies, however, reveals that the motivation was often sociological (e.g. Raper 1977; Fig. 8), and the spatial dimension mainly a means to an end.

The use of statistics can be seen as reflecting a basic uncertainty or incompleteness of evidence and theory. To measure pattern, and to validate its existence, was possible, but often it was impossible to get to grips with behavioural questions convincingly (Hietala 1984; Whallon 1984). Indeed, the factors which disturb a site, or lead to a palimpsest, can be non-random and might well leave it with a pattern still showing statistical significance, with apparent associations between unrelated categories of material. Kroll (1994) notes, for example, the evidence that early hominids repeatedly revisited areas engaging in new activity 'before and after' refuse from previous activities was buried (cf. also Tuffreau et al. 1997).

Uncertainty of interpretation remained even for as important a site as Pincevent, where the state of preservation was quite exceptional. Leroi-Gourhan formulated a theoretical model of the Magdalenian tent or 'house' but Binford (1983), Audouze (1987), Julian et al. (1987) and others have debated the interpretation: would the tent of the '*modèle théorique*' have provided space for the activities? Even on a surface where hardly an item has been moved, there is little agreement about the boundaries of structures (but this need not be true elsewhere, e.g. at Le Cerisier: Gaussen 1980). Hearths, however, are features indicating a focus, and analysis centred on them is one of the most promising ways to evaluate and disentangle key elements (Binford 1983; Stapert and Street 1997).

Spatial archaeology has many uses, but it cannot in itself separate the different levels of activities on a site. It may well leave uncertainties of association (Whallon 1984), and cannot reinstate missing elements. In recent years archaeologists have often sought alternative modes of documentation, which give precise links between components. Lithic refitting has been used very widely, because it provides information both precise and specific (Fig. 9; Peretto and Ferrari 1995; Audouze and Enloe 1997; Böeda et al. 1990; Tuffreau et al. 1997; Villa 1983). The chains of activity can be seen as past human decision paths. In one sense they take us to 'moments in time' but in another to a picture of dynamics: threads extending through time. Even then, as Pettitt (1997) points out, it is necessary to distinguish complex cultural behaviour from simple necessities of biomechanics.

Site formation processes and taphonomy

In Palaeolithic archaeology there was long a simple division in people's minds between sites in 'primary' and 'secondary' context. Simple tests could be used to distinguish between them, and if a site passed, it could be analysed in behavioural terms. Gradually a greater complexity became recognized.

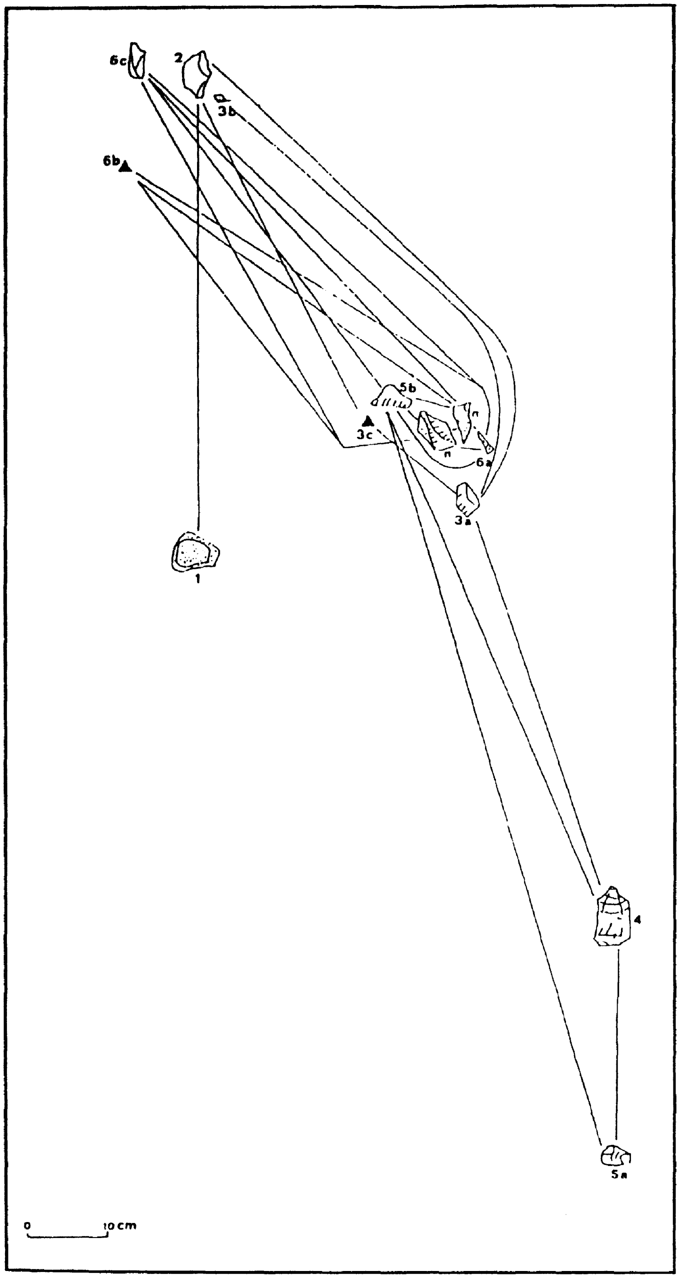

Figure 9 Distribution of a refitting group of artefacts at Ca'Belvedere di Monte Poggiolo after Peretto and Ferrari (1995). The core (n) is in the centre; numbers show the sequence of flake removals. Small pieces recovered in sieve without co-ordinates are represented by black triangles, and shown at the centre of their small 33cm quadrats: a useful technique for meshing different levels of resolution (reproduced courtesy of C. Peretto and F. Ferrari).

Hints of this occur in systems models with their ideas of trajectories, crystallizing out as the systemic context of Schiffer's Behavioral Archaeology (1972, 1976). White and Modjeska (1978) traced artefact movement in an ethnographic context in New Guinea, finding that the relationship between artefacts and behavioural systems 'is rather more complex than commonly assumed'. Schiffer also made important observations about behaviour in clearing (or not clearing) refuse, distinguishing primary and secondary

categories, relevant for example to such matters as the hearth-cleaning at Pincevent (e.g. Schiffer 1983, 1987).

This was only one strand in the recognition of complexity. Leroi-Gourhan had studied the variations in preservation of bone at Arcy, deriving many modern conclusions (Leroi-Gourhan 1964), apart from the work at Pincevent which was implicitly concerned with settlement dynamics, as in the emptying of hearths and transfer of materials (Leroi-Gourhan and Brézillon 1972). Another awakening stemmed from South Africa, in the work of Brain (1967, 1981; Fig. 10), developed also by Isaac (e.g. 1967, 1977) in East Africa. Beginnings of bone studies elsewhere were summarized by Binford (1981).

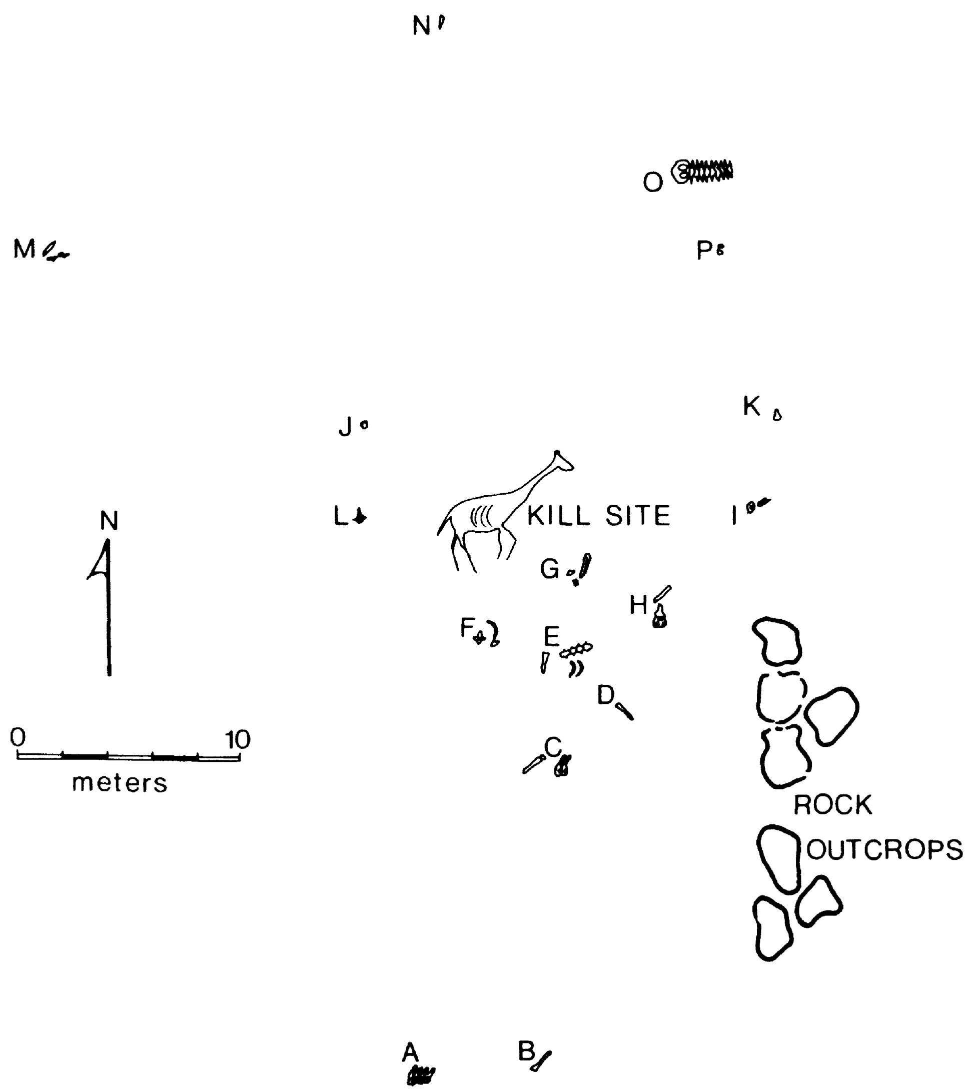

Figure 10 In taphonomy a database of natural evidence is a necessity for comparisons of archaeological evidence. C.K. Brain mapped this kill site of a giraffe in 1969, as disturbed by carnivores over a period of some months. After Brain (1981) reproduced by permission of University of Chicago Press.

The word 'Taphonomy' was suddenly rediscovered and employed to give coherence to a field of study. Meaning literally 'rules of burial', it had been coined by the Russian geologist Efremov and used in palaeontological contexts (Olson 1980). Some of its first uses in English were by Andrew Hill (Hill and Walker 1972), and applications rapidly increased (Behrensmeyer and Hill 1980; Hill 1988; Villa and Courtin 1983).

There were two thrusts to this work: that sites could be studied in behavioural terms only if human and natural factors could be disentangled; second that a methodology was needed which would establish principles of interpretation (e.g. Schick 1987, 1992). Desmond Clark's emphasis on ethnoarchaeology and actualistic principles discerned this as or even before Lewis Binford shaped his views on middle range theory. Formation processes were as important as tracing natural disintegration: the two can be seen as opposite sides of one coin.

In East Africa debates raged over the extent of disturbance of early sites. If they lacked integrity, then complex behavioural models lacked firm support (Binford 1981). The ideas of major hominid involvement, home bases, systematic butchery, needed to be demonstrated not assumed. Gradually improved methodology has worked in this direction: recent developments in this area were brought together by Oliver et al. (1994). They tend to show even greater complexity, but also a greater hominid role. Actualistic approaches have undoubtedly contributed to understanding. Similarly, in Europe where doubts were raised about the supposed elephant hunting at Ambrona and Torralba, purposeful butchery has nevertheless been demonstrated on Middle Pleistocene sites at Aridos and Boxgrove (Villa 1990; Roberts 1986).

The internal timescale of sites (on a micro scale) is still a problem, at almost all periods. Generally we do not have moments in time: or at least, we do not know how thick their containing envelope may be. Stern (1994) has emphasized the difficulties, especially in landscape archaeology applied to early sites, as at East Turkana. There a landscape can be obtained for study only by conflating finds from a series of sediments, perhaps representing 100,000 years or more in total. This does not mean that there can be no highly resolved lenses within such landscapes. Conard (1995) argues that we should treat each site at the appropriate resolution, and points out sanguinely that the Laetoli footprints are not time-averaged. Sites can be studied at high resolution, even if they cannot be related one to another directly in a landscape (cf. Tuffreau et al. 1997). Isaac's methods suggest ways towards comparing sites even where time-relationships are uncertain (Isaac 1977).

Conclusion

This survey has been intended to pick out some strands in the progress towards a high resolution archaeology. It is far from comprehensive: some of the most recent developments can be followed in papers in this volume, which have a common theme to the extent that they point out dangers, but find positive ways forward in dealing with actual data.

High resolution studies are favoured on well-preserved sites. They can operate at the micro-scale (e.g. Matthews et al. 1997), in integrated studies on a medium scale (e.g. Frison 1996; Hayden 1997), or on a large scale. Here they will remain controversial

because of the great costs. Sometimes resolution has to be picked out from massive datasets, which have been confronted by many workers (e.g. Bailey 1996; Hodder 1996; Kroll 1994; Marks 1983; Thieme 1996). The stone ages have some advantage in such studies, because knapped artefacts provide such obvious chains or threads.

The issues of data and resolution are linked but not the same. If archaeology requires large-scale excavations to take place, as often happens, there would be no point in doing this at too low a level of resolution.

Finding a balance between effort, returns and resolution is not easy, nor predictable on first view of a site. Excavators will often wish that they had recorded some extra categories of information, and feel that others showed few results. In recent work at Beeches Pit, a Middle Pleistocene site in Suffolk, UK, all natural stones were kept and recorded in three dimensions like artefacts. This had been the practice with 'manuports' on African excavations. It was questionable whether it made sense in an environment full of natural flints, but a return of taphonomic information seemed possible (Andresen et al. 1996). Recently it became plain that many flints on the site are burnt, sometimes invisibly so. Suddenly there becomes apparent a potential for mapping and comparing the distributions of burning in worked and natural pieces – but this value had not been anticipated. Audouze and Enloe (1997) give an account of the interactive fine-tuning of methods during an excavation, in response to questions and problems that arise. At Verberie and elsewhere the results have been impressive. In general, the efforts pay off.

Can we justify such vast enterprises, given the finite nature of archaeological resources? Should we excavate one 'flagship' site, over thousands of square metres, if this is at the expense of doing twenty or thirty moderate sites? Kroll (1994) suggests that excavations should be larger; and it also seems that the most striking advances of knowledge tend to come from the very large sites excavated over many seasons. In testimony to this, the 1997 conference on Palaeolithic lifestyles at Weimar in Germany voted unanimously to write letters of support for the excavators of Schöningen and Bilzingsleben, so that full justice can be done to finds of the highest significance. This does not exclude theory: indeed if the theoretical issues raised by Clark (1967) and Gamble (1996) were not addressed, and re-addressed, there would be no valid intellectual context for analysing these datasets.

Acknowledgements

The Palaeolithic Lifestyles conference organized by Professor H. Ullrich in 1997 confirmed the value that the international community of archaeology places on high resolution investigations of the most rewarding sites. Editing of this issue was completed during my tenure of a British Academy/Leverhulme Trust Senior Research Fellowship concerned with the archaeology of Beeches Pit. I am grateful to the contributors, whose work has focused my attention on many points relevant to the project as well as to this issue.

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High resolution or optimum resolution? Spatial analysis of the *Federmesser* site at Andernach, Germany*

Dick Stapert and Martin Street

Abstract

This paper discusses spatial analysis at site level. It is suggested that spatial analysis has to proceed in several levels, from global to more detailed questions, and that optimum resolution should be established when applying any quantitative methods in this field. As an example, the ring and sector method is applied to two hearths excavated at the *Federmesser* site of Andernach in Germany. One hearth can be shown to have been present inside a dwelling, while the second one was out in the open.

Keywords

Andernach; *Federmesser* tradition; ring and sector method; hearths; spatial analysis; dwelling structures.

Spatial analysis: dealing with a hierarchy of problems

In the past few decades, Stone Age archaeology has undergone a large-scale transformation. It is no longer a monolith; in fact, the discipline nowadays consists of a conglomerate of surprisingly many and widely varying specialisms. Analytical techniques have developed rapidly and alongside traditional pursuits such as typology, technology, chronology and palaeoecology, other subdisciplines have come of age. The most important ones are refitting analysis, use-wear analysis, raw-material studies, experimental archaeology, ethnoarchaeology, taphonomy and intrasite spatial analysis. As a result, the scope of Stone Age studies has expanded enormously.

A consequence of the flourishing of Stone Age studies is that for any site the amount of data produced may be staggering. It has become a major challenge to integrate the

* This paper is dedicated to Professor G. Bosinski, on the occasion of his sixtieth birthday

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various types of analytical result, both practically and theoretically. To accomplish this, dedicated software has become an inescapable necessity. Ideally, this will be in the form of a computer package that can store and analyse all the data produced by the different analytical approaches. Such a program might help to counter the trend towards fragmentation of Stone Age studies, a danger inherent in the branching into specialisms.

All human activities involving material objects have a spatial component. Technological and typological studies are concerned with artefacts, and the same is true for refitting analysis, raw-material studies and use-wear studies. What binds all these approaches together is the fact that artefacts have a location in space. It is because of this that the spatial aspect has the potential of providing us with an integrative platform. Unfortunately, spatial analysis at site level is often not integrative in the above sense, although promising starting points exist (e.g. Keeley 1991). Moreover, it involved in many cases the use of complex mathematical or statistical procedures (e.g. Blankholm 1991). The output of such techniques is often unsatisfactory and difficult to interpret. More often than not, multivariate procedures have hidden mathematical assumptions which are not well-adapted to archaeological data. The results of complex techniques have often been presented in ways that are so non-transparent that they rather obfuscate than help us to learn something.

The major issue is that there is a hierarchy of basic problems, which have to be approached one by one, ranging from the most global level to ever finer-grained levels. If a complex technique is unleashed indiscriminately on all the data of any site this problem-scale is ignored, with the result that one will lose track in the resulting confusion. The first problem-level obviously concerns the possibility of post-depositional disturbance. There are hardly any sites without at least some disturbance, and one has to investigate the kinds and degrees of disturbance that might have occurred. The second level concerns the question whether one is dealing with a single event or with multiple occupation. Methods of spatial analysis specifically designed to assess the possibility of multiple occupation have hardly begun to be developed (e.g. Stapert and Terberger 1989; Johansen in press b). These problems are complicated enough, and it is a task for the spatial analyst to investigate these matters thoroughly. The quality of the results of any kind of more detailed spatial analysis is dependent on how well these questions have been dealt with. Once the conclusion is reached that one is dealing with a largely undisturbed residue of a single event, new basal questions will turn up on the next level.

On many Upper or Late Palaeolithic sites, hearths have been encountered. The most important question on the third problem-level is then whether or not a dwelling structure was present around or near the hearth and, if so, exactly where and how large this dwelling was. This is an important question, because many interesting issues only become approachable after the 'dwelling problem' has been solved. In the literature we see quite a lot of speculative models often derived from ethnographic sources, but nothing is explained by, for example, projecting the plan of a Nunamiut house onto a distribution map of a Palaeolithic site. The tendency to embark upon 'ethnography with a shovel' (Wobst 1978) is a dangerous one. We have to solve our own problems.

If it has been established whether a hearth was inside a dwelling or out in the open, new questions turn up at the next problem-level. In both cases these questions arise from the time-depth of settlements. In the case of open-air hearths the most important problem at

this level is whether or not wind direction changed repeatedly during the period of occupation. If it did, the whole system of drop and toss zones (Binford 1983) will have rotated with it. In such situations we may in fact be confronted with distributions that largely have a palimpsest character. This disturbing possibility has to be investigated; to a certain extent this is possible by a combination of refitting analysis and ring and sector analysis (for an application of this approach, to the Hamburgian site at Oldeholtwolde, see: Stapert and Boekschoten 1996).

If a hearth was inside a dwelling we have to locate the entrance and to establish in which parts of the site artefacts were present in drop situations (where they played a functional role) and where they were not. Generally, there will be toss zones against the walls of the dwelling, 'door dumps' outside the entrance, and often also dumps at some distance from the dwelling, where waste was discarded collectively (for an example, see the interpretation of the spatial layout, involving toss zones and dumps, of the large dwelling structure at Gönnersdorf II: Boekschoten and Stapert 1993).

Loading all artefact locations indiscriminately in any automated procedure for spatial analysis can hardly result in valuable results. Only after the questions on the four problem-levels discussed so far have been solved, one by one, can it be profitable to look for even more fine-grained patterns, for example discrete activity areas or gender patterns in space.

At all problem-levels, formal procedures of spatial analysis are not sufficient. The approach should rather be to develop methods for integrating refitting results, use-wear data and raw-material data with adequate techniques of spatial analysis, for all specific questions at each problem-level separately, going from global to more local patterns. This is the real challenge, and it is here that an integrated and flexible computer package may be of great importance.

Optimum resolution instead of high resolution

In view of the foregoing discussion, it seems evident to us that the methods for spatial analysis included in such a package should be simple, transparent and playful. Transparency for us means that it should be possible to present the results in a graphical way as clearly as possible. It furthermore means that the analytical methods should be 'honest': i.e. without unwarranted assumptions, and easy to understand for non-mathematically trained archaeologists. For these reasons it is not advisable to incorporate any complex multivariate procedures. It seems wise to start with simple techniques and to use complex techniques only when their application can be convincingly justified in the case of specific questions. Below, a few techniques considered by us to be transparent and graphical will be put to work: ring and sector analysis, and density analysis.

Our methods should also be flexible and have as many analytical options as possible, so that one can 'play about' with spatial data. Playing with spatial data is a much more serious undertaking than it might seem at first sight. The goal is to find structure in the data jungle and playing is part of the pattern-recognition process. An important aspect of the possibility to play is the search for the optimum level of resolution. Many patterns, including spatial patterns, are not indifferent to scale. In other words, one has to focus any method for spatial analysis by establishing the optimum parameters for each site and

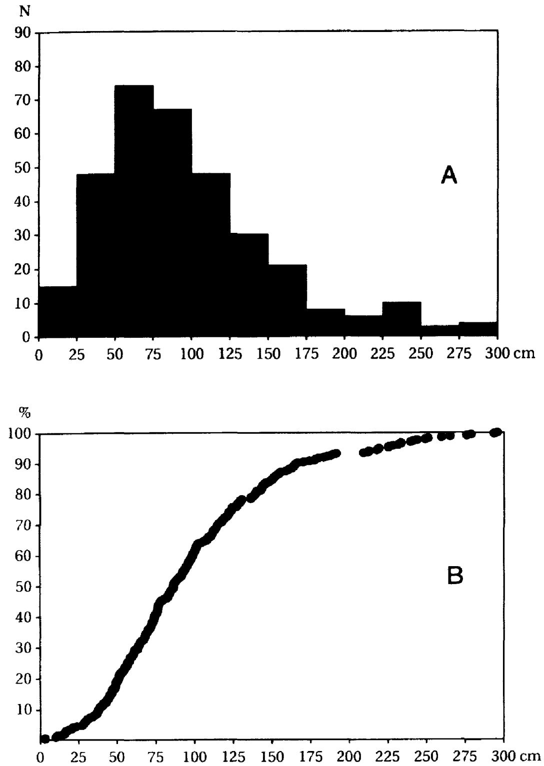


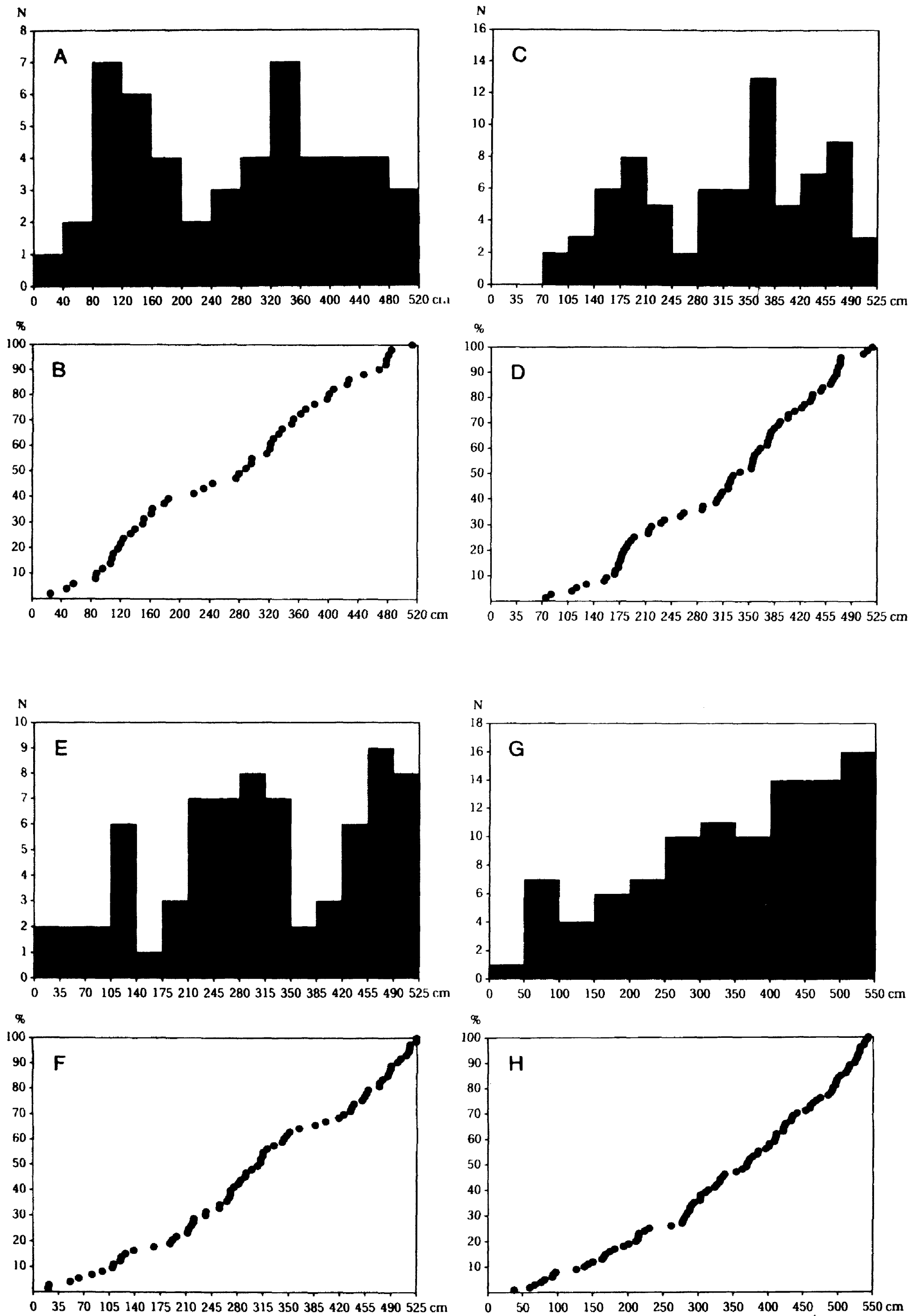
Figure 1 Ring diagram (A) and trace line (B) for all tools within 3 m from the hearth centre at Pincevent T112 (n = 334; based on Leroi-Gourhan and Brézillon, 1972). Zero on the X-axis is the centre of the hearth. In the ring diagram, distance classes (intervals) of 25 cm were employed; in the trace line every individual tool is represented by a dot.

each question individually. This quest is an interplay between the wish to use as much information as possible and the need for statistical reliability. The more artefacts, the more fine-grained our measuring scales can be. A flexible computer program allows one to find the optimum parameters for any method, by going through the whole measuring scale.

One of the aims of this paper is to suggest that it is not so much desirable to go for 'high resolution' in our work, but instead for 'optimum resolution': the search for the highest level of resolution which still produces realistic patterns. In most cases this will not be the same as the highest possible resolution. Below, we will illustrate some of the principles outlined here, using the *Federmesser* site at Andernach as an example. First, however, the methods and tools used in our work have to be introduced.

The ring and sector method

The ring and sector method was designed as a simple tool for spatial analysis of sites with a 'central hearth', more or less in the middle of an artefact scatter (Stapert 1989; 1990a and b; 1991/92; 1992; Stapert and Terberger 1989). The idea behind the method is that the hearth attracted many activities and played an important role in the social life of small groups of people (for example families). Using rings and sectors around the hearth centre is therefore a straightforward way of charting spatial patterns in such situations. The


A
B
C
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E
F
G
H
N
%
0 40 80 120 160 200 240 280 320 360 400 440 480 520 cm
0 35 70 105 140 175 210 245 280 315 350 385 420 455 490 525 cm
0 50 100 150 200 250 300 350 400 450 500 550 cm
10 20 30 40 50 60 70 80 90 100

method is closely related to Binford's hearth model (Binford 1983). In a ring analysis, the frequencies of artefacts in distance classes are counted per type, and presented in histograms (see Figs 1 and 2).

One of the most important applications of the method relates to the question whether a hearth was located within a dwelling or in the open air. The ring diagrams obtained for some thirty Palaeolithic or Mesolithic sites in Europe were found to be of two types: unimodal, as in Figure 1, or multimodal, as in Figure 2. Unimodal ring distributions, as shown by the tools at Pincevent T112, are characteristic for hearths in the open air. Artefacts that were tossed away were not stopped by tent or hut walls, with the result that ring frequencies gradually decrease away from the hearth. Multimodal ring diagrams, as in the case of the backed bladelets at Gönnersdorf II, are thought to be typical for hearths inside dwellings. The first peak reflects the drop zone near the hearth. The second peak was caused by the 'barrier effect' of the walls, stopping centrifugal movements (of course, a barrier effect will be largely absent at the entrance). A third peak, if present, mostly reflects the door dump(s) located outside the entrance.

An alternative way of presenting distance data, avoiding arbitrary class divisions, is the trace line or ogive: the cumulative frequency diagram (see Figs 1 and 2). In the ANALITHIC package (see below), all individual artefact locations are shown as dots in the trace lines. Unimodal ring distributions result in characteristic S-shaped trace lines, while multimodal distributions produce several S-shaped parts following each other in the trace line. If a hearth was located eccentrically or if the dwelling was not round but oval, ring diagrams (or trace lines) should be made per sector, for example per quarter (as in Fig. 2).

The ring approach has recently been tested by applying it to an archaeologically visible dwelling structure at a Palaeo-Eskimo site at the western coast of Greenland ('Ikkarlusuup Tima' dating from the Dorset Culture: Stapert and Johansen 1995/6). In that paper several improvements of the ring and sector method are suggested, including procedures to make it applicable for grid-cell data if the cells are not larger than 50 × 50 cm.

The ANALITHIC project

The ANALITHIC project is a joint venture of the archaeological institutes of the universities of Groningen (Dick Stapert) and Copenhagen (Lykke Johansen) and a software developer in Groningen (Akili Software B. V.: Gijsbert Boekschoten and Manfred Schweiger); several other researchers are also involved. The main goal of the project is to develop an integrated computer package for intrasite spatial analysis of Stone Age sites. By the end of 1997, the package should include modules for cartography, ring and sector

Figure 2 Ring diagrams and trace lines per quarter for all backed bladelets at the large Concentration II of the Magdalenian site at Gönnersdorf in Germany (based on data kindly provided by Sabine Eickhoff; see Eickhoff 1989). A and B: NE quarter, n = 51; C and D: NW quarter, n = 75; E and F: SW quarter, n = 73; G and H: SE quarter, n = 100. In three quarters bi- or trimodality can be clearly seen; the absence of clear multimodality in the SE quarter probably indicates the location of the entrance. Note that the ring widths in the histograms may vary; this is a result of establishing the optimum resolution in each case.

analysis, density analysis (e.g. Cziesla 1990), refitting analysis (e.g. Cziesla ibid.; Johansen in press a and b) and use-wear analysis (e.g. Keeley 1980; Moss 1983). Attributes of raw materials, typology and technology, traces of burning, evidence of fracturing, etc., can also be stored and analysed. The first three modules mentioned above are included in the already available RINGS and SECTORS computer program ('R&S' for short: see Boekschoten and Stapert 1993, 1996; Stapert in press). The new version is being assembled under WINDOWS, and after completion the package will be renamed ANALITHIC. It will allow integrative spatial analysis, involving all kinds of data. For example, it will be possible to study ring and sector distributions of selected use-wear attributes or categories of refitted artefacts, or to combine refitting data with use-wear data, and so on.

All analytical modules in ANALITHIC will offer optimizing options, such as finding the sector system with the richest possible sector or the density grid with the richest possible cell (some examples illustrating these procedures are provided below). Moreover, the program has the option to compare two sets of data; for example, it is possible to transform density maps into proportion maps, expressing the percentage of a specific artefact class with respect to a larger selection, over all the cells. The same is possible for ring and sector analysis. Optimizing procedures may also be applied to proportion data; for example, it is possible to find the density grid with one (or more) cells having the highest possible percentage for one tool type.

In order to test the computer package, a complete data file under the format of the ANALITHIC package, including refitting and use-wear data, is built for the Hamburgian site at Oldeholtwolde in the Netherlands (see Stapert 1982; 1986; Stapert et al. 1986; Moss 1988; Johansen in press c). In May 1996, a congress was held at Groningen University to present the ANALITHIC package under construction. Moreover, papers on spatial analyses of several well-preserved Palaeolithic sites in northern Europe were presented by archaeologists from Denmark, Germany, Belgium and The Netherlands (Johansen and Stapert in prep.).

The *Federmesser* site at Andernach

The Martinsberg in Andernach is situated where the Rhine leaves the flat and open Neuwied Basin and flows through the narrow channel of the Andernacher Pforte ('Andernach Gates') into the narrow Rhine Gorge. The site was discovered in 1883 following quarrying of pumice of the Laacher See volcano (around 11,000 14C BP; see Hajdas et al. 1995; Lanting and van der Plicht 1995/6; Street et al. 1994) and partially excavated by Hermann Schaaffhausen. Several episodes of late glacial human occupation are known at the site; excavations from 1979 to 1983 and from 1994 to 1996 have identified four zones of Magdalenian occupation and two main areas of younger Final Palaeolithic (*Federmessergruppen*) activity, one of which will be examined by this paper. Bone from the Final Palaeolithic assemblage at Andernach was dated by the Oxford Radiocarbon Accelerator Unit, giving a pooled mean of 11,960 ± 81 BP. While a longer interval between deposition of the bones and their burial below Laacher See pumice is consistent with the stratigraphic position of the *Federmessergruppen* assemblage, the individual dates are heterogeneous and should be treated as an approximation only. It is nevertheless certain

that the site was occupied during the Allerød interstadial and the hunted fauna is of temperate to boreal type, comprising beaver, chamois, elk, a large bovine (aurochs?) and, particularly, red deer (see Baales and Street 1996; Street 1993).

The lithic assemblage is typical for the *Federmessergruppen* (broadly comparable to the Azilian) in the Central Rhineland. Technology is unskilled in comparison with that of the Magdalenian and poor quality nodules of several types of raw materials appear to have been used indiscriminately. Tool supports are normally elongated flakes, probably struck by direct hard or soft hammer technique after only rough preparation of the striking platform. Material was apparently knapped on an *ad hoc* basis and usable supports were simply selected from among the flakes. The tool spectrum is dominated by short scrapers and backed points. The latter include carefully made convex *Federmesser* points, but also specimens with only partial retouch and others with straight backed edges. The short scrapers are in some cases manufactured on very irregular flakes. Burins are rare and those present are relatively poorly worked. Irregular, terminally and laterally retouched tools are also present. A particular feature is the presence of simple oblique end-retouched microlithic forms, but backed bladelets are unimportant and could often simply be medial fragments of broken backed points.

Thirteen varieties of raw materials were recovered, representing a total of perhaps twenty less than fist-sized nodules. Raw material sources range from very local (lydite and silicified limestone obtained from the Rhine gravels), via regional (quartzite outcrops in the Westerwald and Eifel), to exogenous (with distances over 20 km). Within the last group, chalcedony comes from sources close of Bonn *c.* 40 km away to the north, while Baltic flint points to sources at least 100 km to the north. Artefacts of different varieties of Meuse flint demonstrate contact between the central Rhineland and flint-bearing regions in the Meuse drainage area *c.* 100 km to the north-west (so-called Meuse eggs could have been collected at gravel sources somewhat closer). Other materials such as siliceous tuff and siliceous oolite possibly represent contact with sources in the Mainz Basin some 40–100 km south of the site (for a recent discussion of raw materials in the Central Rhineland see: Floss 1994; see also Baales and Street 1996).

A concentration of Final Palaeolithic lithic and faunal material some 10×8 m in diameter can be defined. It appears that this was more or less completely recovered despite partial destruction of the site. Within this larger zone of activity each lithic raw material has a more or less distinct centre of distribution, interpreted as knapping scatters. Flint is found more commonly in the west of the site (but with refits to material in the eastern part of the site), while quartzite has an overall eastern distribution (Bolus 1984). Conjoining sequences show that all stages of artefact manufacture took place within the excavated area. All large mammal limb bones were intensively marrow smashed and refitting shows that body parts of the same individual were scattered across the entire occupation area (Street 1993). The overall spatial patterning of bone fragments resembles that of the lithic assemblage and underlines the unity of the excavated assemblage.

Refitting studies show that the *Federmessergruppen* assemblage has remained horizontally largely *in situ*, but has been 'dilated' vertically, probably by bioturbation, with bones and lithics of this horizon found through the depth of the colluvial *Lößlehm* deposit overlying the Magdalenian settlement structures. The vertical spread is of no importance for the present analysis. The site was dissected by a deep fissure in the basalt bedrock, still open to

a great depth at the time of the Magdalenian occupation of the site but largely filled with sediment by the Allerød. Secondary reworking of *Federmessergruppen* material into the fissure is therefore limited, particularly in the part of the site under consideration here.

At Andernach hearths are not characterized by red coloration of the soil, unlike at the contemporary neighbouring site, Niederbieber (Bolus 1992). Concentrations of burnt bone, quartz and lithic debitage and of charcoal, unrecognized during excavation, were first rendered visible by the subsequent plotting and refitting of these materials and three of the concentrations are interpreted as the locations of hearths. Just as in the case of Niederbieber, hearth locations are most reliably indicated by dense scatters of burnt bones (Street 1993). The reconstructed hearths were not associated with evident structures and possibly represent only short episodes of use of fire.

In some cases they can be more closely characterized, for example a fire in which willow wood (*Salix*) was burned was in use during the butchery or consumption and discarding of one or two beaver carcasses. Burnt postcranial beaver bone is found almost exclusively in m^2 21/86, with only single fragments in the adjacent m^2, whereas the unburnt skull and tooth fragments are scattered to the north-west and south-east. Willow charcoal is also concentrated in m^2 21/86 and in the southern half of m^2 21/87, with a diffuse scatter to the west. This episode is equivalent to hearth B of the present spatial analysis of lithics.

Hearth A of the present analysis is associated with burnt bone of red deer (*Cervus elaphus*), fragments of ribs, pelvis and femur being found concentrated at co-ordinate 19/86.25. Fish bones, including a burnt specimen from m^2 19/86 identified as pike (*Esox lucius*), can also be linked to this episode. It is interesting that a number of the burnt bones were found at an unusually great depth for the Final Palaeolithic assemblage, lying almost directly on the much older Magdalenian living floor. One explanation for this anomaly would be that a fireplace at this position was dug into the surface. (An alternative interpretation might be a structural post-hole adjacent to a hearth. It is not possible to link charcoal of any particular species directly to this hearth). Both birch and willow charcoal are found at this position, and pine charcoal is also found only slightly further to the east.

Still further to the east, and outside the area considered by the present analysis, a concentration of partly refitted burnt quartzite artefacts and bones of a young ungulate suggests the presence of a third hearth in the shallow depression of the infilled fissure at m^2 25/86. No charcoal was found at this part of the site, possibly due to downslope erosion.

Although no evident dwelling structures were recognized during excavation, accurate spatial recording of the lithic assemblage and the post-excavation recognition of hearth locations allow the application of the ring and sector method at Andernach to establish whether or not indications for dwellings exist, hidden as *structures latentes* in spatial distributions of lithic artefacts.

Density analysis: hearths and raw materials

Spatial analysis was carried out for the area west of the above-mentioned fissure, which runs across the site between and parallel to co-ordinates X = 24 and 26. To the east of the fissure, artefact density is much lower than in the west, and the only hearth in that area is located very close to the fissure, a circumstance hindering a reliable application of the ring

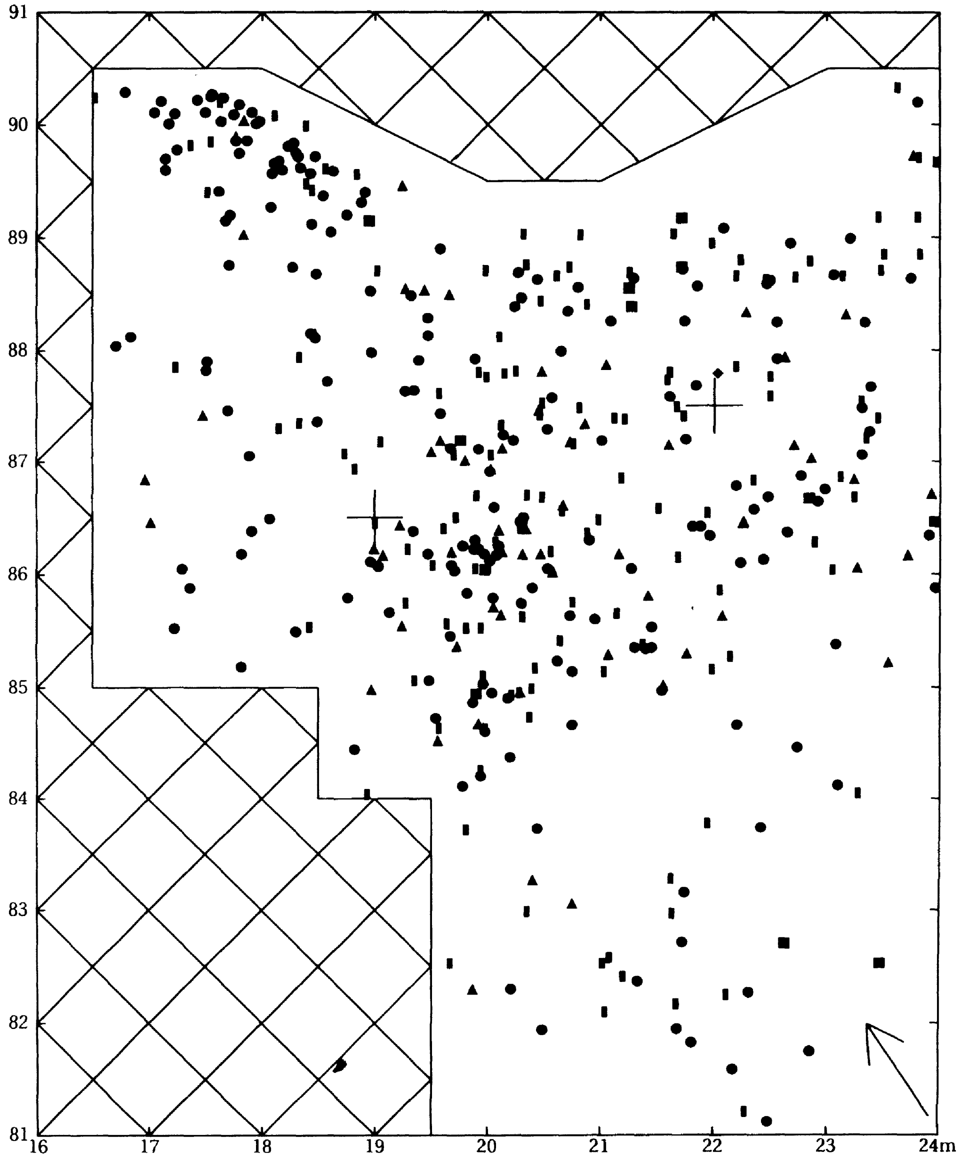


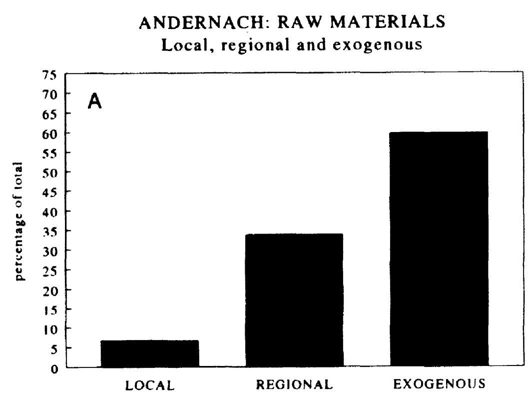
Figure 3 Andernach: distribution map of the 403 artefacts within the analysed area. Crosses indicate hearths: A (19/86.5) and B (22/87.5). Key: triangles = tools; squares = cores; rectangles = blades or bladelets; lozenge = retoucher made of lydite; circles = other artefacts.

and sector method. The analysed area is rather small for any type of spatial analysis: only about 56 m^2. The present analysis is based on the 403 artefacts with exact co-ordinates in this area (Fig. 3).

In the analysed area two hearths could be reconstructed (see above): Hearth A (centre at X = 19/Y = 86.5) and Hearth B to the east of A (centre at X = 22/Y = 87.5). The centres of the two hearths are only 3 m apart, which is rather close for application of the ring and

sector method. To make things worse, thirteen types of raw material can be distinguished at Andernach: two local materials (lydite and silicified limestone), two regional materials (grey and light-grey Tertiary quartzite) and nine exogenous materials (chalcedony and Baltic flint from the north, five types of Meuse flint from the north-west or west, and siliceous tuff and siliceous oolite from the south). The spectrum is dominated by exogenous materials: about 60 per cent of the total of 403 lithics with exact co-ordinates; local materials only make up about 7 per cent (Fig. 4A). Among the exogenous materials (Fig. 4B), Meuse flint is the most common (about 83 per cent). The two northern materials make up only 4 per cent and are represented by six chalcedony artefacts and four Baltic flints (the latter are exclusively tools, including two scrapers and one *Federmesser* point). For a discussion of possible explanations for this raw material spectrum, which suggests a local territory of some 200 km in diameter, see Baales and Street (1996).

The first step in any spatial analysis of Andernach obviously must consist of establishing which raw materials are associated with either Hearth A or Hearth B, or both. To investigate this, both distribution maps and density maps were prepared for each raw material separately. For lack of space we will only show a few of these; a series of density maps using a grid with cells of 50 × 50 cm is presented in Figure 5. The grid position with the richest possible cell (or cells) was calculated in each case by the R&S program, thus bringing out the 'centres of gravity' for all types of raw material.



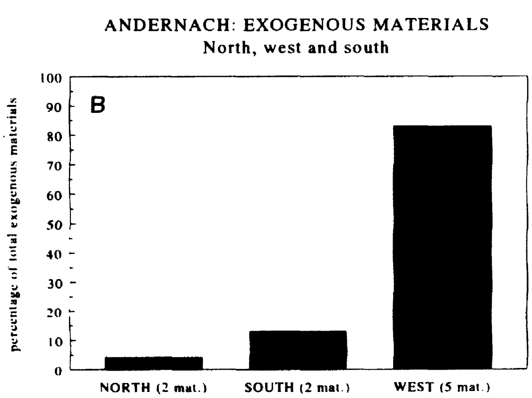
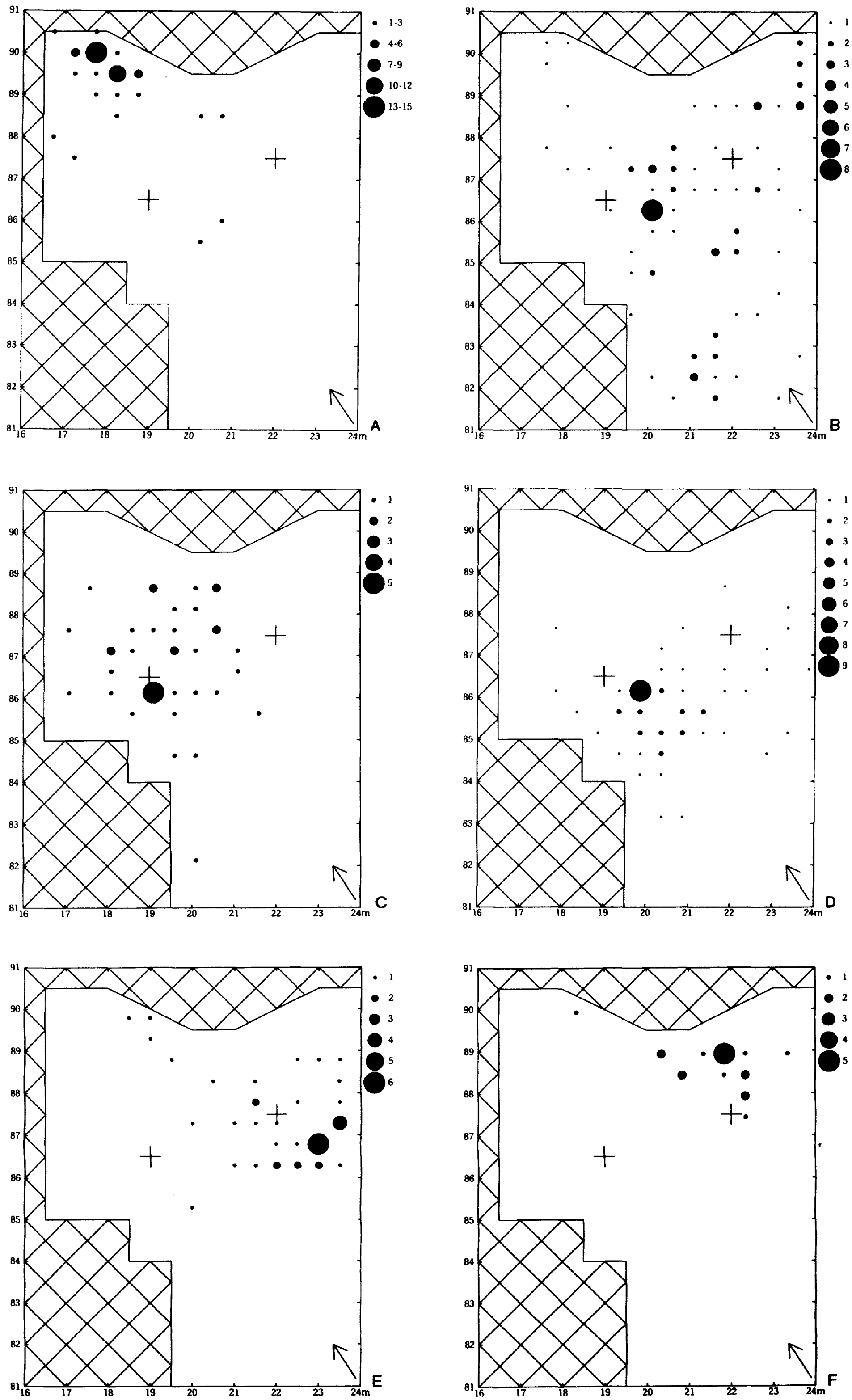


Figure 4 A and B: raw materials at Andernach, as reflected by all artefacts with exact co-ordinates in the analysed area. Local materials could have been collected within 1 km from the site and regional materials between 1 and 20 km, while exogenous materials must derive from sources more than 20 km away. Several exogenous materials, coming from the north, west and south, must have been carried over distances of at least 100 km.

Figure 5 Andernach: density maps for several types of raw materials. A: Black Meuse flint, n = 58; B: Light-grey Tertiary quartzite, n = 96; C: Eluvial Meuse flint, n = 39; D: Meuse-gravel flint, n = 56; E: Grey Tertiary quartzite, n = 40; F: Siliceous tuff, n = 19. The R&S computer program has calculated the grid position with the richest possible cell, thus indicating the 'centre of gravity' for each raw material. Grid cells are 50 × 50 cm. Hearths A (west) and B (east) are indicated by crosses.


A
1-3
4-6
7-9
10-12
13-15
B
1
2
3
4
5
6
7
8
C
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4
5
D
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24m

Two materials do not seem to be clearly associated with either of the two hearths: chalcedony and black Meuse flint. There are only six chalcedony artefacts, scattered over the southern part of the analysed area and away from the two hearths. Black Meuse flint occurs tightly clustered in the extreme north (Fig. 5A). This concentration consists largely of flakes and chips; it is probably part of an originally larger flint-knapping residue cut off by the excavation borders. Though a few artefacts of this material were present elsewhere, including some tools in the vicinity of Hearth A, it is omitted from ring and sector analysis since the bulk of this material forms a separate cluster, which is incomplete and situated away from the hearths.

All but one of the remaining eleven raw materials can be clearly associated with either Hearth A (eight materials including all five types of Meuse flint) or Hearth B (two materials). The exception is light-grey Tertiary quartzite, which occurs near both hearths (and elsewhere) although its 'centre of gravity' is near Hearth A (Fig. 5B). The associations established by density analysis can be found in Table 1. The overall clear correlation between hearths and raw material types makes a meaningful ring and sector analysis possible. It should be noted, however, that the correlations are not perfect. Several artefacts made of materials associated with Hearth A (especially Meuse-egg flint and Meuse-gravel flint) were present near Hearth B (the reverse occurs rarely or not at all). This again suggests that the hearths are connected; as noted above, refitting of lithics and bones has shown the unity of the analysed area.

Table 1 Raw materials: number of artefacts with exact co-ordinates in the western part of the excavated terrain, and associated hearth or hearths

Raw material	*Number*	*Hearth(s)*
Local materials:		
Lydite	20	A
Silicified limestone	7	A
subtotal:	27	
Regional materials:		
Light-grey Tertiary quartzite	96	A and B
Grey Tertiary quartzite	40	B
subtotal:	136	
Exogenous materials:		
Black Meuse flint (NW)	58	–
Meuse-gravel flint (NW)	56	A
Eluvial Meuse flint (NW)	39	A
Meuse flint type Vetschau (NW)	31	A
Siliceous tuff (S)	19	B
Meuse-egg flint (NW)	15	A
Siliceous oolite (S)	12	A
Chalcedony (N)	6	–
Baltic flint (N)	4	A
subtotal:	240	
Total:	403	

Ring analysis: the dwelling problem

On the basis of the above results, ring analyses were performed for both hearths. In the case of Hearth A, all artefacts of the nine raw materials associated with it in Table 1 are used, including light-grey quartzite. The reason for the latter's inclusion is that the two types of material clearly associated with Hearth B, siliceous tuff and grey quartzite, occur clustered to the east of that hearth: away from Hearth A; it is therefore reasonable to assume that the same is true for those artefacts of light-grey quartzite that 'belong' to Hearth B. Artefacts made of siliceous tuff and grey quartzite provide the data for the analysis of Heart B. For both hearths, all locations within 3 m of the hearth centres were analysed. The above decisions result in a total of 199 artefacts for the analysis of Hearth

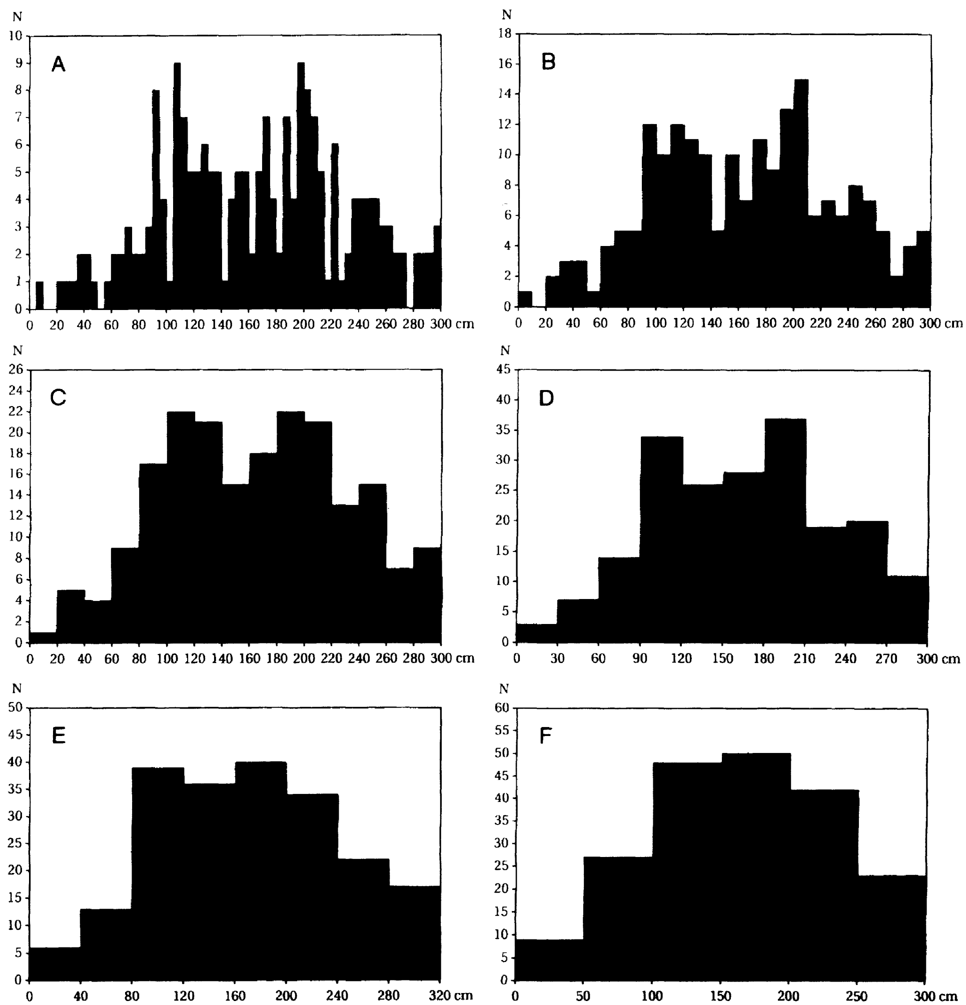

Figure 6 Ring diagrams for the artefacts (n = 199) of nine raw materials associated with Hearth A at Andernach, using rings 5, 10, 20, 30, 40 and 50 cm wide.

A, and only 59 for Hearth B. In both cases there are hardly any chips (pieces smaller than 1 cm) among the analysed artefacts (A: n = 1; B: n= 2); most chips collected at Andernach derive from the sieve and are not considered in this paper.

We will start with Hearth A. As noted earlier, it is important to establish the optimum resolution; this turns out to be a crucial question in this case. In Figure 6, ring diagrams for the 199 artefacts around Hearth A are shown, using rings of 5, 10, 20, 30, 40 and 50 cm. For the first three of these it is clear that ring widths are too small: the curves show many irregularities. Nevertheless, bimodality can be observed. With rings of 30 cm the graph has stabilized. It is a bimodal diagram with the second peak between 1.8 and 2.1 m, suggesting the presence of a tent or hut with a diameter of about 4 m. In the diagram using rings of 40 cm, bimodality has become all but invisible. In the case of rings 50 cm wide, the graph has changed into a unimodal histogram, and the bimodality which is evident when we use smaller rings has been lost. This state of affairs illustrates very well the importance of a dedicated computer program. We can then easily go through the whole scale of measurement, from fine- to coarse-grained, in order to establish the optimum resolution: the first level on which the graph is stabilized.

It is interesting to produce ring diagrams for different groups of artefacts, in order to see how persistent the bimodal pattern is. We have selected bladelets, including retouched ones (Fig. 7A, n = 35), and all tools except retouched bladelets (Fig. 7C, n = 35), both shown in rings of 30 cm. Although their numbers are rather small, both artefact groups

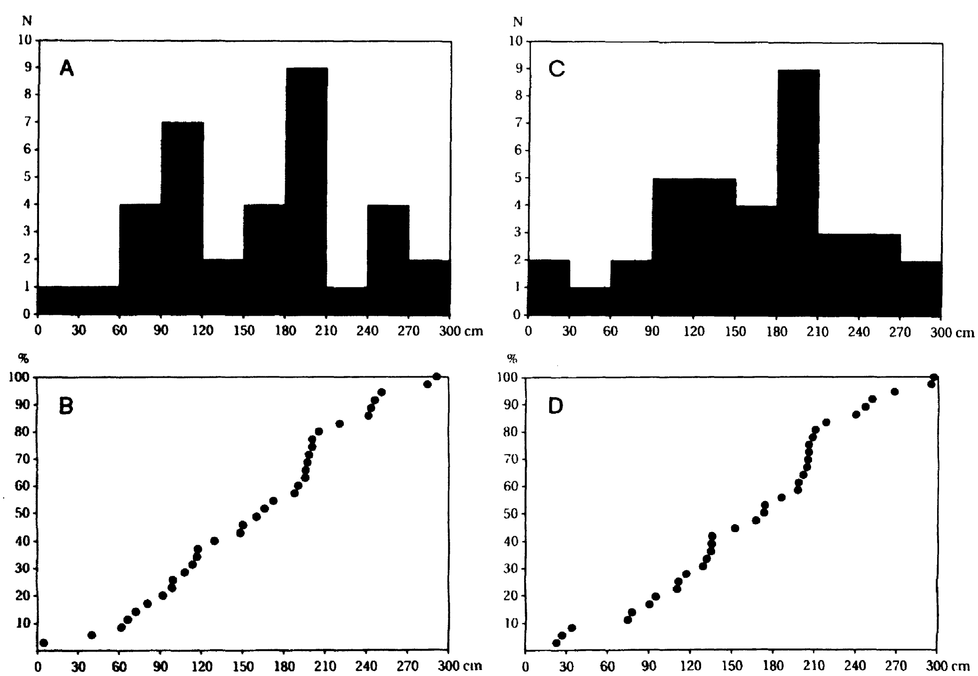

Figure 7 A and B: ring diagram and trace line for the bladelets, including retouched ones, around Hearth A (n = 35); C and D: ring diagram and trace line for all the tools, except retouched bladelets, around Hearth A (n = 35).

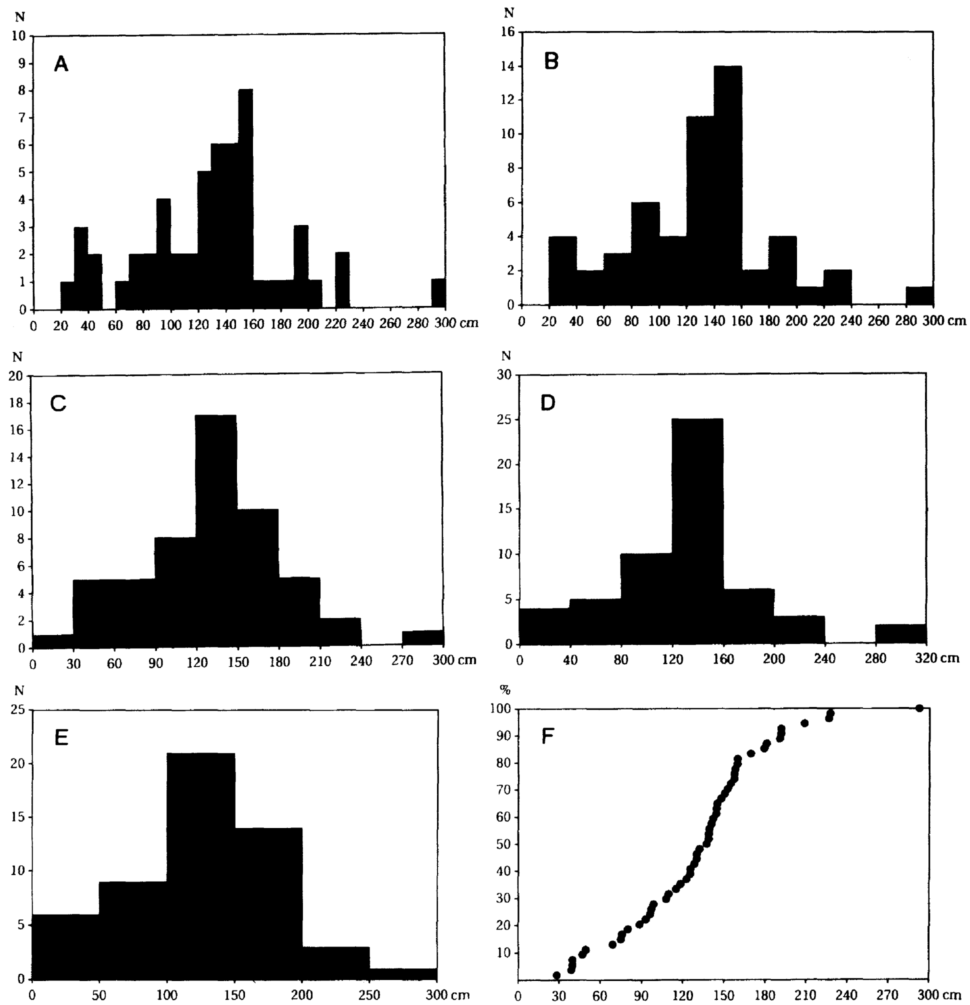

Figure 8 A–E: ring diagrams for the artefacts (n = 59) of two raw materials associated with Hearth B at Andernach, using rings 10, 20, 30, 40 and 50 cm wide; F: trace line for the same artefacts.

show a clear second peak between 1.8 and 2.1 m. For both groups, trace lines are presented below the ring diagrams. These trace lines are remarkably similar and indicate the beginning of some kind of wall at about 2 m from the hearth centre. Only 59 artefacts are associated with Hearth B; their distance distribution is shown in Figure 8, using rings of 10, 20, 30, 40 and 50 cm. In all diagrams we are basically dealing with a unimodal pattern, suggesting that this hearth was in the open air. Note that the trace line for Hearth B (Fig. 8F) is similar to the one for Pincevent T112 (Fig. 1B). The only mode occurs between 1 and 1.5 m from the hearth centre, which is a very normal distance in unimodal diagrams obtained for other sites (see Stapert 1989).

We may conclude that Hearth A was inside a dwelling, while Hearth B was out in the open. But how reliable are these ring diagrams? We would like to briefly discuss a problem

commented upon by several colleagues (e.g. de Bie 1992), i.e. that rings grow in surface area going outwards from the centre. Would it not be better, therefore, to transform ring frequencies into densities? The first author has always avoided this transformation because ring analysis can be considered a one-dimensional approach, dealing with distances (see for a further discussion of this issue: Stapert and Johansen 1995/6). Nevertheless, the rings are located in two-dimensional space and we should take account of that, especially when some rings used in our analysis are incomplete (as is the case at Andernach).

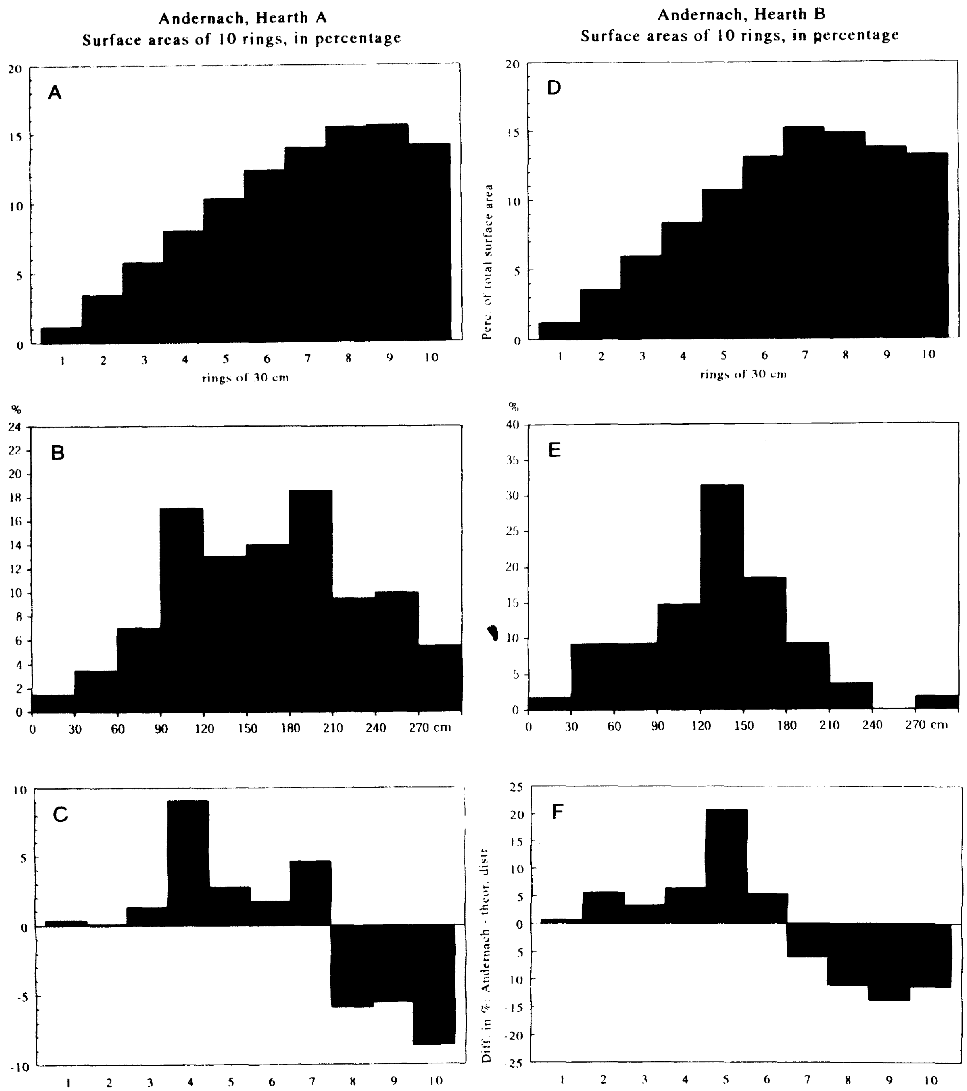

Figure 9 A and D: surface areas of ten rings of 30 cm width around the centres of Hearths A and B, expressed as percentages of the total areas; B and E: observed ring diagrams for Hearths A and B, expressed as percentages; C and F: deviations from the theoretical curves of A and D as displayed by the observed distributions of B and E.

Moreover, the surface areas of the rings may give us an impression of what would be expected in a totally random situation. In Figure 9, the surface areas of ten rings of 30 cm around Hearth A (A) and Hearth B (D) are expressed as percentages of the total area within 3 m from the hearth centres. Note that the last two or three rings are incomplete, and therefore do not continue the normal linear growth of ring surfaces. These figures represent what we would expect the ring distributions to look like in the case of totally random artefact scatters. It is of interest to compare the observed ring diagrams for the two hearths (presented again in Figure 9B and E, but now expressed as percentages) with those reflecting randomness. In Figure 9C and F, the deviations from the theoretical random curves are shown, positive or negative, as displayed by the actual ring distributions for Hearths A and B. As can be seen, the bimodal pattern for Hearth A is still in evidence, and especially noteworthy is the plummeting through the zero line going from ring 7 to ring 8, at about 2.1 m, reflecting the barrier effect of a wall. In the case of Hearth B there is only one peak, as before, and the crossing of the zero line is much more gradual.

Apart from comparing observed ring distributions with theoretical ones reflecting randomness, the above procedure also has the merit of correcting for incomplete rings. A third advantage is that this procedure can be adapted to make it possible to use grid-cell data for ring and sector analysis, a matter we cannot go into here (see Stapert and Johansen 1995/6).

Sector analysis: segmentation of the space around the hearths

For both hearths, eight sectors within 3 m from the hearth centres were employed (in principle, the optimum resolution could again be searched for, but since sector analysis is less vulnerable than ring analysis we have omitted this step here for lack of space). Let us first look at the general picture: Figure 10. These are 'sector graphs', which in fact are combinations of pie charts and bar graphs. In a sector graph, the centre has the value zero; the circumference represents the mean number of artefacts per sector. Sectors with a frequency higher than the mean have a black bar outwards; sectors with lower frequencies have a white bar inwards. The R&S computer program positioned the sector wheel after calculating its richest possible half, which is the SE half for Hearth A, and the E half for Hearth B. Note that, in the case of Hearth B, two richer areas are shown in the graph, one in the NE (siliceous tuff) and one in the SE (grey quartzite): compare with Figure 5E and F. The richest sector in the case of Hearth A is in the SE, probably reflecting the entrance (a relative absence of the barrier effect can be demonstrated in that sector, but we cannot

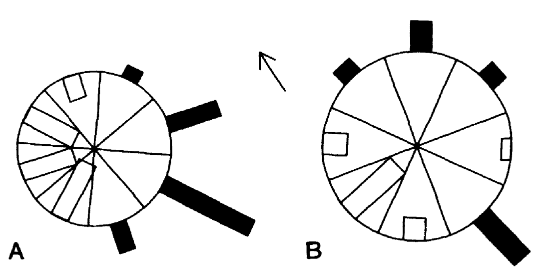

Figure 10 Sector graphs for Hearths A and B. Eight sectors are employed for the artefacts within 3 m from the hearth centres. The centre has the value zero; the circle represents the mean number of artefacts per sector. In both cases, the sector wheel with the richest half is shown.

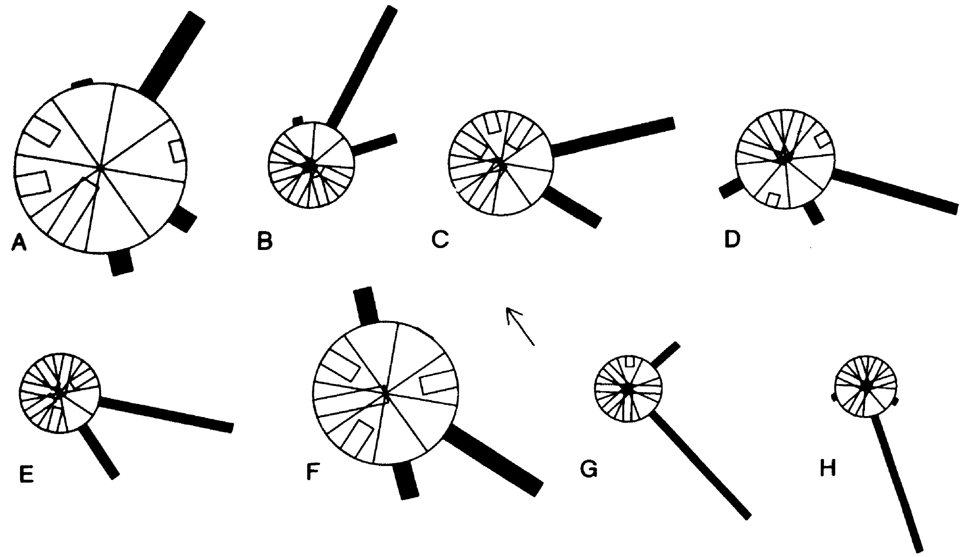

Figure 11 Sector graphs for eight raw materials associated with Hearth A; locations within 3 m from the hearth centre in 8 sectors. In each case, the 'richest sector option' of the R&S computer program was used. Key: A - Eluvial Meuse flint, n = 38; B - Meuse flint type Vetschau, n = 27; C - Light-grey Tertiary quartzite, n = 40; D - Siliceous oolite, n = 11; E - Meuse-gravel flint, n = 44; F - Lydite, n = 16; G - Meuse-egg flint, n = 12; H - Silicified limestone, n = 7.

go into details here). The poorest site-half in the case of Hearth A, opposite the presumed entrance, could have been a sleeping area.

The R&S program can also position the sector wheel by calculating the highest possible frequency in one of the sectors only: the 'richest sector option'. This procedure results in powerful visual representations of any tendencies to spatial segmentation that may exist around a hearth. For eight of the nine materials associated with Hearth A, sector graphs showing the richest sector are given in Figure 11 (the omitted material is Baltic flint, since there are only four artefacts with exact co-ordinates). The sector graphs clearly reveal a quite strong segmentation of the space around Hearth A. In the extreme north of the richest half we find two types of Meuse flint (eluvial Meuse flint and Meuse flint type Vetschau; Fig. 11 A and B). In the extreme south we encounter the two local raw materials (lydite and silicified limestone; Fig. 11 F and H) and two other types of Meuse flint (Meuse-gravel flint and Meuse-egg flint; Fig. 11 E and G). The remaining materials occur especially in the artefact-rich area near the entrance, where also all other materials are represented.

It is not clear what caused the observed segmentation. One hypothesis might be that the interior space of the dwelling was divided into halves according to sex. However, the numbers of 'projectiles' (backed pieces) – supposedly mainly male tools – and of scrapers – supposedly mainly female tools – in the two quarters of the richest half do not support this idea. There is hardly any difference between the two quarters in this respect (according to the chi-square test, two-tailed p = 0.7). Nevertheless, it seems probable that (at least) two different persons occupied the dwelling, exploiting different raw materials.

The same could be true for Hearth B. Since it probably was in use only briefly, changes in wind direction could have been absent during its functioning. The different locations

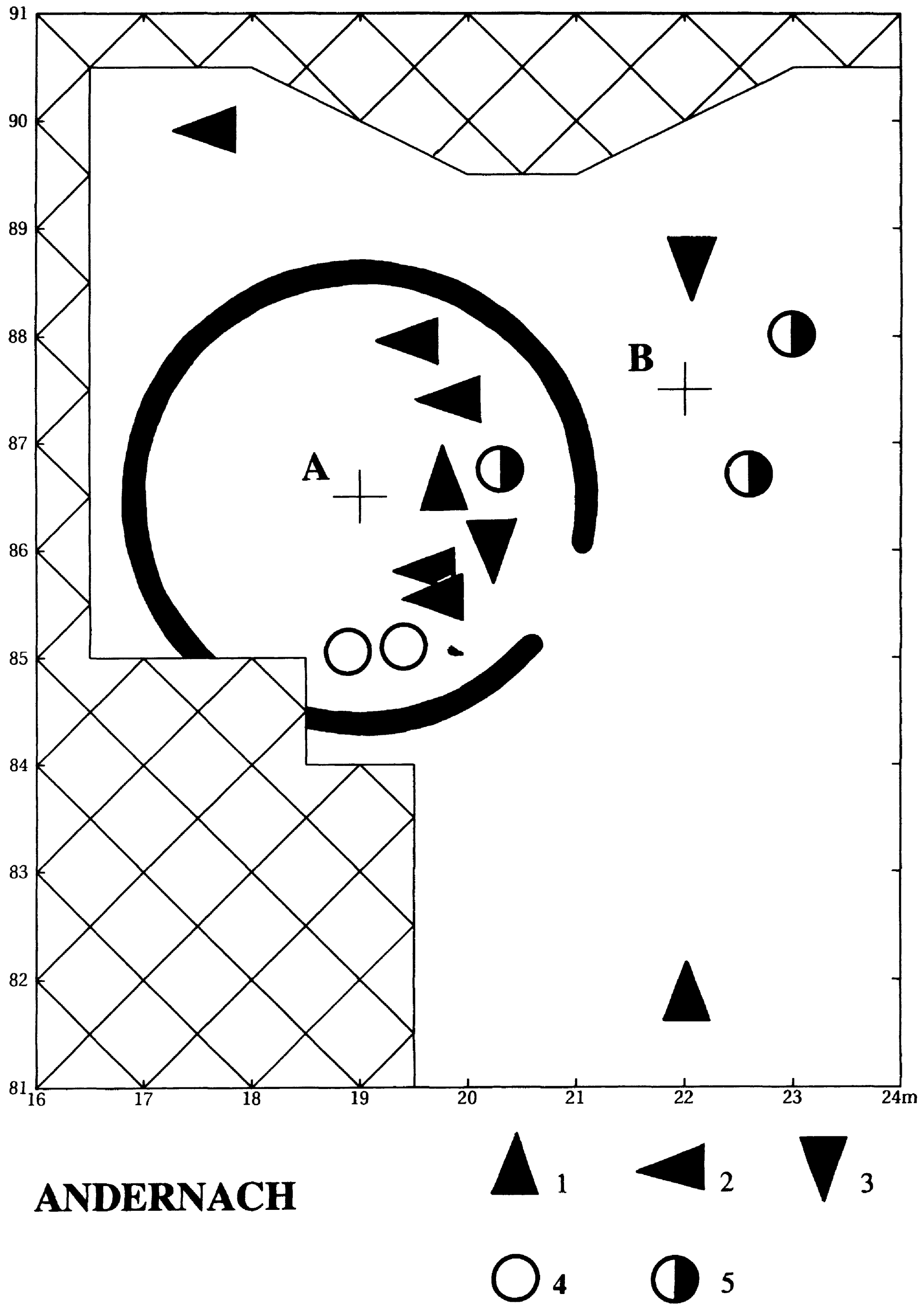

Figure 12 Schematic plan of the western part of the excavated area at Andernach, showing some results of the ring and sector analysis. Key: 1 - exogenous materials from the north (Baltic flint and chalcedony); 2 - exogenous materials from the north-west (5 types of Meuse flint); 3 - exogenous materials from the south (siliceous oolite near Hearth A and siliceous tuff near Hearth B); 4 - local materials; 5 - regional materials (light-grey Tertiary quartzite near hearths A and B, grey Tertiary quartzite near Hearth B). Hearth A is presumed to have been located inside a dwelling structure with a diameter of about 4 m. Drawing Dick Stapert/Lykke Johansen.

of the two raw materials associated with this hearth may therefore reflect two different persons sitting near the fire. These might have been the same two persons who occupied the dwelling.

Some conclusions

At the site of Andernach, two hearths were analysed by the ring and sector method. One was most probably inside a dwelling with a diameter of about 4 m, while the second was probably in the open (see Figure 12). On the basis of refitting, it can be supposed that both hearths were in use during the same occupation; the analysed area must be considered as only a part of a much larger 'site complex'. It is of interest that the hearth inside a dwelling was a dug-in hearth.

In this paper it is suggested that when using quantitative methods in spatial analysis, it is of great importance to establish the optimum level of resolution. This seems to be crucial especially in applying the ring method: too wide rings may easily obscure multimodality in the case of relatively small dwellings. A computer package such as ANALITHIC allows one to explore the whole scale of measurement in order to establish the optimum resolution, i.e. the highest resolution which still produces reliable patterns.

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All figures in this paper, except Figure 12, were produced using the computer program RINGS and SECTORS.

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High resolution archaeology at Verberie: limits and interpretations

Françoise Audouze and James G. Enloe

Abstract

Verberie is a late Palaeolithic site with high resolution in the preservation of archaeological materials and their spatial configuration. While excellent preservation offers great promise for the interpretation of past human behavior, it cannot be assumed that this is a totally pristine site. Post-depositional pedogenetic processes have eradicated stratigraphic bedding of the sediments, leaving a methodological challenge for the archaeologists to separate materials from multiple occupation lenses, which have retained most of their spatial integrity. Impressionistic back-plotting, statistical analysis of artefact elevations, and refitting of flint, fire-cracked rock and reindeer bones have contributed to deciphering the depositional puzzle. These have revealed artefact associations and spatial configurations which can be given well-founded behavioral interpretations derived from experimental and ethnoarchaeological research.

Keywords

Verberie; Upper Palaeolithic; micromorphology; hearths; refitting.

High resolution: real or imagined?

High resolution archaeology might be seen as the dream of every field archaeologist – a perfectly preserved site, no natural or post-depositional disturbances, in short, no Schifferian N- or C-transforms (Schiffer 1987: 22). All too often, the dream is just that, more a figment of the archaeologists' imagination than a depositional reality. The archaeological record is a far more complex phenomenon, one that requires considerably more sophistication in its reading. Binford (1981a) has suggested that, while much of the archaeological record has suffered greatly from preservation and disturbance problems, the task of the archaeologist is not to dismiss those data as distorted nor to seek only the pristine as usable, but rather to find ways to use the bulk of the archaeological record in a productive manner. We must keep this in mind even when we are dealing with the rare and unusual cases of superior preservation of archaeological materials.

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High resolution archaeology refers not only to excellent preservation of artefacts and objects themselves, but also to the integrity of their spatial configurations, which are presumed to represent organizational aspects of human behavior rather than of geological processes. Even when an archaeological site appears to have been not at all or only minimally altered from its original behavioral context, that very judgement must be demonstrated rather than assumed. One may find that the terms 'pristine' or 'disturbed' are misnomers; we might more realistically seek to evaluate the degree of integrity or disturbance. Such a perspective might allow us to realize that different levels of resolution may characterize an archaeological deposit, requiring varied procedures for reading the record and extracting behavioral information for different classes of data. This appears to be the case in the methodological problem presented to us by the late Upper Paleolithic site of Verberie (Audouze et al. 1981; Audouze 1987; Audouze and Enloe 1991).

Evaluating the resolution level and its limits

In a high resolution archaeological site, it is essential not to be captivated by the good – even exceptional – preservation. We must precisely evaluate under which conditions or for which categories of observations the high resolution can be assessed. In fact, the high resolution may not be valid for all categories of remains (e.g. not for both stone artefacts and bones). The site of Verberie provides a very good example in this respect.

This late Magdalenian open air site is composed of superimposed lenses of archaeological artefacts which are embedded in multiple layers of silt deposited by repeated floods of the River Oise. Because of their thinness and the spatial integrity of the distributions of artefacts, these lenses can be considered as living floors. Six lenses or occupation levels have been identified so far. The thickness of each lens varies across the extent of each level, from the thickness of a single artefact to that of several when artefacts are piled up in dumps. The different lenses of occupation are separated from one another by silt of varying thickness and may even rest upon one another in places when two dumps are superimposed.

A series of characteristics puts Verberie in the category of high resolution archaeological sites. Each lens is flat with a thickness of less than 10 cm (except for the top one slightly perturbed by the plough). Faunal remains, ranging from reindeer to rodents, are well preserved. Features typical of Upper Paleolithic settlements can be observed: hearths with their circular linings of stones as the central basin; tool concentrations around the hearths; and concentrations of flint refuse. The distribution of artefacts in well-delimited concentrations is independent of any gravitational factor (slope movement). Their orientation shows no signs of any taphonomic factor apart from the few pieces which have been aligned by plough furrows in the top level. The artefact concentrations have a varied content: from flint refuse, the result of knapping activities, to mixed dumps filled with heated stones, reindeer bones and flint flakes and blades. The density of artefacts varies from one concentration to the next with no gravity effect apparent anywhere. At a finer level of observation, we find many bones still articulated: vertebrae found by series of five to ten (Plate 1), carpal or tarsal bones – the latter often still in connection with a distal tibia, radius with ulna, etc. At an even finer level of observation, it can be observed that

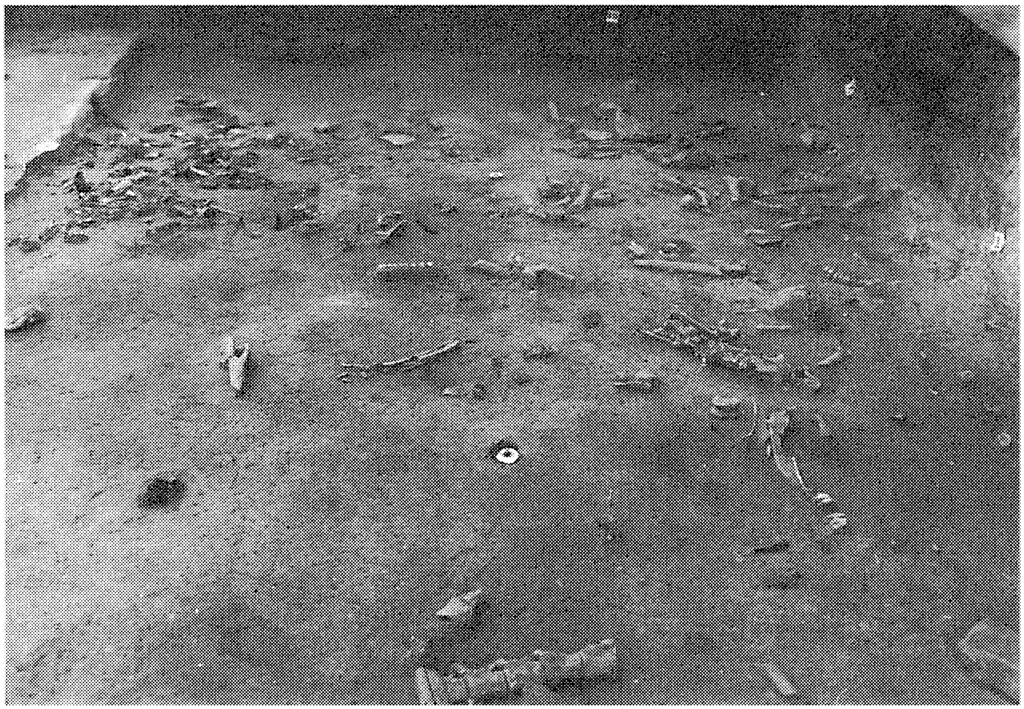

Plate 1 Intact segment of vertebral column *in situ* in level 11.3 of squares K-L1 1-12. Note also the maxillary dental series in place with thin cranial bone not preserved (photo F. Audouze).

bones are often full of old cracks but they are still entire and fall into pieces only if they are not hardened before being lifted.

This information is sufficient to establish the high resolution nature of the archaeological site. It would be unwise, however, to assume that the high resolution is good for all the components of the site. In fact, there is a major discrepancy at Verberie between the precise preservation of artefact positions and the situation of the embedding silt. At the artefact level, it is already possible to observe that intense percolation of water has taken away most of the ocher and charcoal. The first is only present as spots underneath flint pieces, usually trapped in carbonate. The latter is only represented by micro-particles (2 to 5 mm: see Wattez 1994) which give a dark hue to the sediment inside the hearths or the ash refuse areas. The main disturbance comes from the bioturbation which has been very active for a long time. This is primarily a result of worm activity, but insects have also homogenized the sediment which is composed of flecks of quartz, calcite and glauconite, and was originally deposited in successive thin layers. Though successive layers of silt deposited by floods can be discerned, the sediment has been so intensely homogenized that there is no way to record these alluvium layers through photographs, drawn profiles or even latex stratigraphic peels as at Pincevent. This means that, while the artefacts are *in situ*, most of the sediment has been reorganized. As a consequence, the smallest elements – flint, stone and bone chips created from processing activities – cannot be considered *in situ*. While their position in two dimensional space does not seem to have varied a lot (this can be deduced from their position relative to concentrations of larger

artefacts), their present vertical position may derive from postdepositional processes. Thus the information which can be deduced from their presence can only be used in association with more firm information. Micromorphological analyses performed on sediment sampled from a hearth indicate a change in the sediment density (Marie-Agnes Courty, pers. comm.).

High resolution sites seem the most appropriate archaeological sites to test hypotheses about camp spatial organization and social organization, particularly when, as at Verberie, we assume that the site was created by the remains of several short-term occupations and is composed of successive living floors (we will not discuss here the relevance of the term living floors applied to Verberie: we consider that a living floor, though exposed as a two-dimensional surface, always has a minimal thickness at least). But if we want to make paleoethnological inferences it is vital to discriminate the successive occupations. The more we want to draw assumptions from the positions of artefacts, the more strictly we must control stratigraphy. Otherwise, the inferences drawn from the data may turn out to be biased through mixing of several occupations. Thus we are paying more and more attention to stratigraphic control, in order to control our inferences on seasonality and on the size and composition of the hunting group size. This is particularly tricky at Verberie, first because of the proximity of the successive living floors (five in 25 cm), and second because of the homogeneity of the sediment which does not permit any discrimination on the basis of sediment layers. After twenty years of excavation, it is clear to us that no single method is sufficient to solve the stratigraphic problem and that several complementary methods must be applied according to a heuristic procedure.

Stratigraphic control

The technique of digging naturally aims at exposing horizontal living floors as defined by the bases of the horizontal artefacts. It is impossible to rely on it completely. Not all students are always good diggers, and additionally in the case of piled dumps, and of pieces turned oblique or vertical by rodents or by later Magdalenian trampling, it is sometimes impossible to know where one living floor ends, and where another one starts.

Taking vertical photographs of the excavated meter squares before lifting the artefacts is usually preferred to drawings because it fixes an image of the dug square at a known moment in time, whereas drawings can always be enriched later. Moreover, photographs have a focus which gives a sense of depth. In several occurrences, photography has been very helpful in identifying digging errors when part of a meter square has been at one level and the rest at another one.

Since 1991 we have used an electronic theodolite connected to a microcomputer and have been able to record three-dimensional coordinates of all the artefacts (larger than 2 cm) with much more precision than before. In addition, we are able to take multiple readings on elongated objects, from which we can read orientation and inclination. The fine-grained data are thus immediately on the hard disk and can be easily and quickly converted to horizontal or vertical plots, or can be analysed statistically.

Vertical profiles allow us to inspect the range of thickness of material in an occupation level and the amount of sediment separating it from its neighbours. Figure 1 shows the

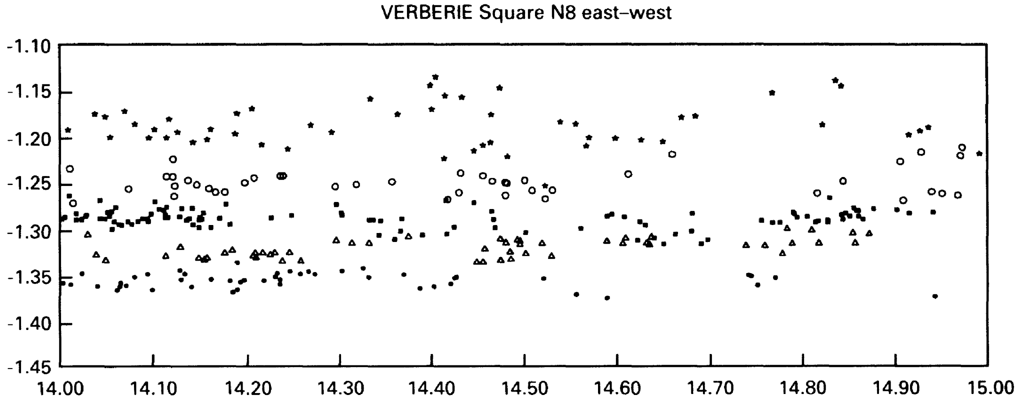

Figure 1 Vertical profile back plot of elevations of artefacts in square N8 (stars = II.1 ; open circles = II.2 ; solid squares = II.21; open triangles = II.22 ; solid circles = II.3).

vertical distribution of artefacts in square N8: note the discontinuous clusters of artefacts assigned to levels II.1, II.2, II.21, II.22 and II.3. Dibble and McPherron's (1994) plotting program also permits the display of objects from which multiple measurements were taken. Thus we can see whether objects are lying flat, thereby giving a good indication of the original ground surface of the living floor; or if they are are tilted at a greater inclination, either from being piled up in a heap of flaking debris, or in a general dump, or because they have been moved up or down by postdepositional forces. These last items can be excluded from spatial or statistical analysis of a level if their vertical position makes the level assignment ambiguous. We count more on the flat objects to define the base of the level and can use them (and the artefacts measured by single points which have similar elevations) with a greater degree of confidence in recognizing and interpreting behaviorally significant human activity patterns.

But if this method is very useful for analyzing the relation between the vertical and oblique pieces and the bulk of horizontal artefacts, the scatter of the pieces in the vertical dimension is frequently too complex for making inferences from the observations of profiles. A few automatic stratigraphic methods exist, but they rest on assumptions we already know not to be valid at Verberie. They usually proceed by attributing pieces to a given layer on the basis of its pre-defined limits, conceived as two horizontal or subhorizontal planes, and of the coordinates of the pieces. They aim at maximizing the layer content while minimizing the inter-layer content. It is not the horizontality which creates a problem (a given angle with horizontal can be introduced in the mathematical definition of the plane), but rather *limits conceived as planes:* occupation layers or living floors are not parallepipedic volumes, they are irregular lenses with a greater volume at the locations of flint refuse areas or stone and bone dumps. While it is possible to estimate the base levels of lenses precisely from the bases of the artefacts, their top limits vary greatly according to the height of the artefacts. A stone, 20 cm thick, and a flint bladelet, 3 mm thick, may rest at the same level, on the same living floor/layer, but their upper surfaces give a highly variable limit to the layer. In fact, the tops of big stones appear in higher layers.

We thus need some statistical control of the stratigraphy. This is why we eventually selected histograms of distribution per square meter. The underlying assumption is that if a living floor is an occupation lens, the levels of the bases of its artefacts will be organized in a normal distribution curve, with most of the artefacts located more or less at the mean level of the living floor. This corresponds with the empirical observation made first by Leroi-Gourhan at Pincevent when he spoke about an 'optimum de decapage' (exposure optimum) (Leroi-Gourhan and Brézillon 1972). When plotting all the artefacts found in a given meter square, we find a curve with several peaks corresponding to the different 'optima de decapage' (Fig. 2).

In order to reduce biases due to bioturbation, oblique and vertical pieces are eliminated, and in difficult cases only large horizontal artefacts are plotted because they are less likely to have moved. In the best cases, we find zero values which mark the interlayers. But even in areas of high density, a sharp decrease can be observed at the limit between two layers. There are only two exceptions: areas of large dumps which are much thicker than the rest of the layers, and those which rest directly one upon the other. Such a situation occurs between layers II.1 and II.2 in the largest dump. Its material relates the two hearths. However, the composition of the dump altered, with bones replacing flint

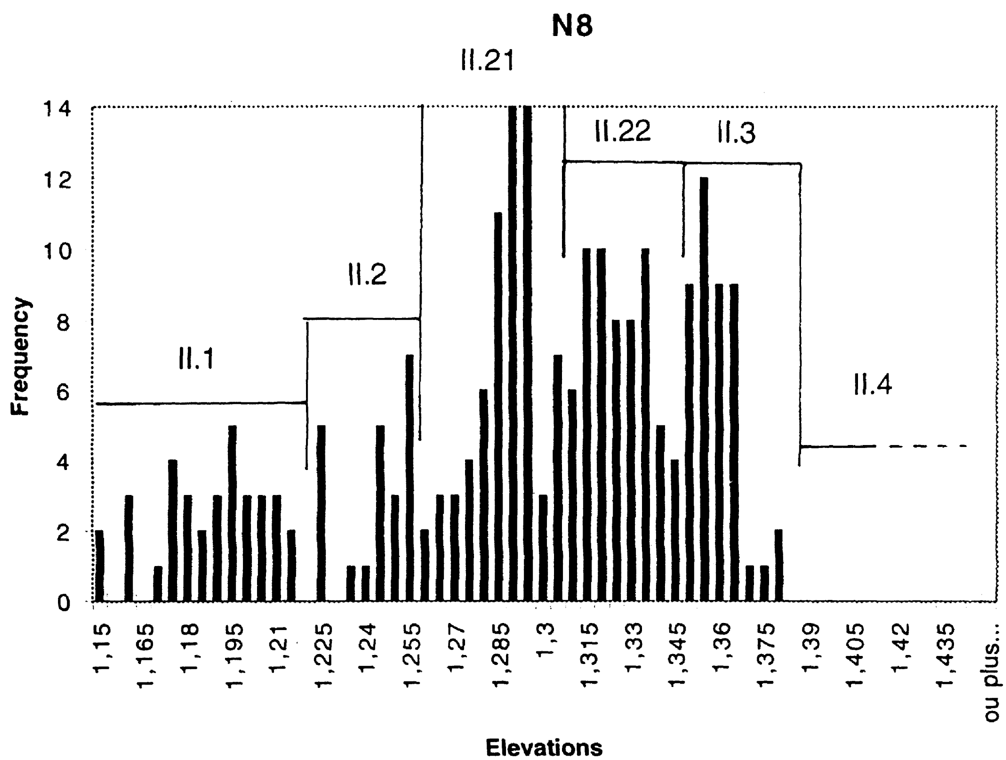

Figure 2 Histogram of elevations of square meter N8. Note clear peaks indicating mean elevations of occupation levels, particularly for II.21, II.22 and II.3. Note the sharp decrease at –.1.22, –1.26 and –1.345 which mark the discontinuity between levels II.1 and II.2, between II.2 and II.21 and between II.22 and II.3.

flakes in the later phase. This situation also occurs between layers II.21 and II.22, where two dumps of identical mixed content are directly superimposed. They can, however, be very clearly distinguished in the neighboring meter squares.

This method allows us to identify the variations of inclination but also accounts for the variability in thickness of the layers. It has even permitted us to discover the presence of two additional layers, currently identified during the excavation, but which had not been dug as separate entities at the beginning. A few years ago, the distribution curves indicated four very strong peaks separated by low values in what had been dug as three layers. The histograms allowed us to go back to the plans and find that the division often had a correlate in the excavations, because two successive exposures had been necessary to complete the uncovering of the original layer (II.2 was subsequently divided into II.2 and II.21). It was then possible to redraw plans for every layer. More recently, this new layer was redivided into two layers (II.21 and II.22), when a hearth was found during excavation away from the dump area. It was surrounded by stones, the bases of which had levels intermediate between the layers II.21 and II.3. Through analyzing the altitudes of meter squares away from the dump in a distribution histogram, it was again possible to identify a decrease in density strong enough and stable enough from one square meter to the adjacent ones to identify this intermediate layer.

Micromorphology

Micromorphological analyses which bring so much information about the history of sediment during and after the occupation raised a lot of hope when Courty et al. (1994) proved that living floors left typical micromorphological signatures. Unfortunately, these signatures are at the micromillimetric level and we have for the moment no way to correlate these micromorphological surfaces with our archaeological living floors – virtual surfaces defined by the bases of artefacts of different thickness. Moreover, at Verberie, micromorphological analyses indicate that bioturbation disturbed these surfaces, which are found as relics at different elevations (Wattez 1994). These floors engendered by human trampling seem to be better preserved in caves than in open air sites but in both types of site they raise a problem. Such pedologic floors are much more numerous than the living floors inferred from archaeological digging. One possible explanation is that, in between two identified occupations, other camps settled in the vicinity and resulted in extended stepped surfaces beyond them. In any case it invites caution about the uniqueness of occupation at any time.

Refitting patterns

The refitting of various kinds of artefactual materials has yielded information that permits evaluation of stratigraphic identifications, and that can subsequently be interrogated in a search for patterns of human behavior. Although these studies are best developed for technological analysis of flint-knapping and the identification of areas of such activities on archaeological sites, much recent progress has been made in application of refitting analysis to other materials (Hofman and Enloe 1992).

Flint refitting performed by Daniel Cahen (1981) on the local flint indicates relations between the Dl hearth and its surrounding activity area, other neighboring activity areas and the big central dump. Flint-knapping activities seem to have been conducted in a slightly different way than at Pincevent or Etiolles. Most concentrations of knapping debris are secondary refuse, mixing several knapping operations. The only exceptions are one area in square J1 where Pierre Bodu found that an 'exotic' brown bartonian flint had been knapped and left *in situ* and its refuse mostly left at the spot or distributed in the large neighboring dump. The very few complete blades and tools are distributed in the neighboring meter squares, and near the second hearth (M20). The second exception is a knapping area close to the Dl hearth, which may have been used to knap two local blocks of excellent quality and with a more sophisticated technique, in order to produce long blades which seem to have been taken away. The big central dump thus looks like a central place in the occupation and connects the two hearths.

Refitting work is not yet completed, but raises more problems than in the other Magdalenian sites from the Paris basin. The scatter in secondary position of the very homogeneous, black or grey local flint makes refitting much more difficult than in the cases of the relatively infrequent 'exotic' flints. The small amount of refitting completed on the local flint has indicated only short linkages, consisting most often of a spatial cluster of all the remaining debris from a flint nodule knapping episode. Rarer 'exotic' flint may connect the two hearths, but only by identification of the distinctive flint rather than by actual refits.

Refitting of hearth stones allows us not only to connect the D1 hearth with the big central dump but also to add a time dimension to analysis of the occupation. A small piece of limestone found in the bottom of the hearth turned out to be part of a much larger block, pieces of which were found in the big central dump. We may thus infer that the blocks which surround the hearth are part of renewed construction of the hearth after broken heated stone had been removed. This may represent the last of one or more cleanings and renewals of the hearth. We may thus infer that the Ml hearth, which is only partially surrounded by a lining of small stones, and is full of small stones, flint pieces and bones, is at a more advanced stage of use, but before cleaning.

Bone refitting can serve both methodological and interpretive purposes. Mechanical refits of fragments of the same bone, coupled with identification of bilateral pairings or adjacent articulations in limb bones of reindeer, can be used to evaluate contemporaneity within an identified occupation surface. Since food from animal resources is not of the same order of durability as flint resources, we would not expect reuse of the same pieces at any later date: and such objects thus serve as a test of the temporal separation of lenses identified as different occupation levels (Enloe 1991).

Interpretation of the patterning

It is only after we have evaluated and determined the integrity of content and spatial configuration in the archaeological site that we can move to an interpretation of the patterning for understanding human behavior. How can we best give meaning to the patterning we find in spatial patterning on high resolution archaeological sites? This must rely on well-founded knowledge about human behavior and most particularly its expression in

spatial configurations of material culture that might be preserved in the archaeological record. Many statistical models of association, variation, etc. can yield robust patterning, but the challenge is in its interpretation. It is at this point that Binford's (1977: 1–10, 1981b: 21–30) arguments about middle range theory are most important. We must have sound linkages between the patterns observed in the archaeological data and our interpretations of those data. Perhaps the two most useful middle range theoretical developments for making such linkages come from experimental archaeology and from ethnoarchaeology. Our ability to read and understand the distinctive patterns that result from known kinds of behaviors depends in turn on the resolution of archaeological sites, both in preservation and in excavation and recording. If we have performed our tasks well, and have been able to demonstrate that the patterning we can see is a result of human behavior rather than of geological or other natural processes, we can look for significant signature patterns in the artefactual content and spatial configuration of materials on the archaeological site.

At Verberie, the biometrics of the human body and its effects on the spatial organization of work and its material correlates allow us to make linkages between the patterns we have found and our interpretations of them. There are significant differences between utilization of interior space and utilization of exterior space, between standing and seated work, between intensive, heterogeneous activities and extensive, homogeneous activities. Binford's (1978b) suggestions on understanding drop and toss zones and the organization of space use around hearths have allowed the reconstruction of specific kinds of tool-manufacturing and tool-use activities. This has been seen in the flint refitting previously mentioned. We can also use these principles to understand the association of artefact distributions and hearth features, such as shown by the corona of tools around hearth L8 in Plate 2.

Ethnoarchaeology can provide models for the identification and interpretation of material patterning in the archaeological record. While we cannot, and should not, expect isomorphic identity between lifeways of modern and prehistoric peoples, an understanding of some principles of the organization and content of distributional patterns will allow us to see how and where those principles may be expected in archaeological situations. One of the clearest principles that does not rely on ethnic identity concerns the differences between intensive and extensive space use. At Verberie, the hearths clearly served as foci for a variety of domestic and technological activities. We can compare the density and distribution of several different kinds of artefactual debris to recognize those activities and to draw inferences about how the use of space was coordinated or sequenced for those activities. We can compare those patterns with other Magdalenian sites such as Pincevent (Enloe et al. 1994). Other activities clearly require more space and are so messy as to preclude sharing that space with other activities. One such activity is primary butchering of large mammal carcasses, requiring extensive use of space, but not necessarily adjacent to the hearth. Binford (1983: 124, 169–70) provides an ethnoarchaeological description of Nunamiut activities and the patterning of their archaeological remains that allows identification of one particular mode of butchering, for which we can recognize content and configurational analogs repeatedly in several occupation levels at Verberie. We can discern relatively empty circular areas surrounded by reindeer bones, particularly articulated vertebral column segments, phalanges and other low food utility skeletal elements (Plate 3). These are located peripheral to the artefact concentrations adjacent to

Plate 2 Corona of lithic debris, especially rich in retouched tools, surrounding hearth L8 in level II.21 (photo F. Audouze).

Plate 3 Portion of empty circle of butchering area in level II.22 of squares I-K/4-7, surrounded by reindeer bone fragments, with unretouched flint blade knives in the center (photo F. Audouze).

the hearths. This corresponds to the patterning that Binford identified for primary butchering. In addition, in the middle of the areas devoid of bone debris, we find unretouched flint blades of the kind Keeley (1981) has identified as carrying meat polish on their edges. This not only tells us about the internal organization of space use in the campsite, but it also helps confirm an identification of the site as primarily a hunting camp.

The horizontal distributional patterns of refits and linkages between dispersed elements of a single reindeer carcass can inform us about sequences of skinning, disarticulation and butchering procedures on the site. These are largely consistent with the butchering areas away from the hearths and the domestic activity areas adjacent to the hearths. Additionally, they can serve as the basis for inferences about carcass-partitioning relevant to the social distribution of meat and food sharing (Enloe 1991, 1992, 1994). Figure 3 shows the spatial distribution of refitted elements of portions of eight individual reindeer carcasses on level II.1. Although there are linkages evident between the DI and M20 hearths, the majority of the refits link the hearths to, or are concentrated in, the main dump in G-H-I/17-18-19. There is thus limited evidence of social interaction between the two hearth

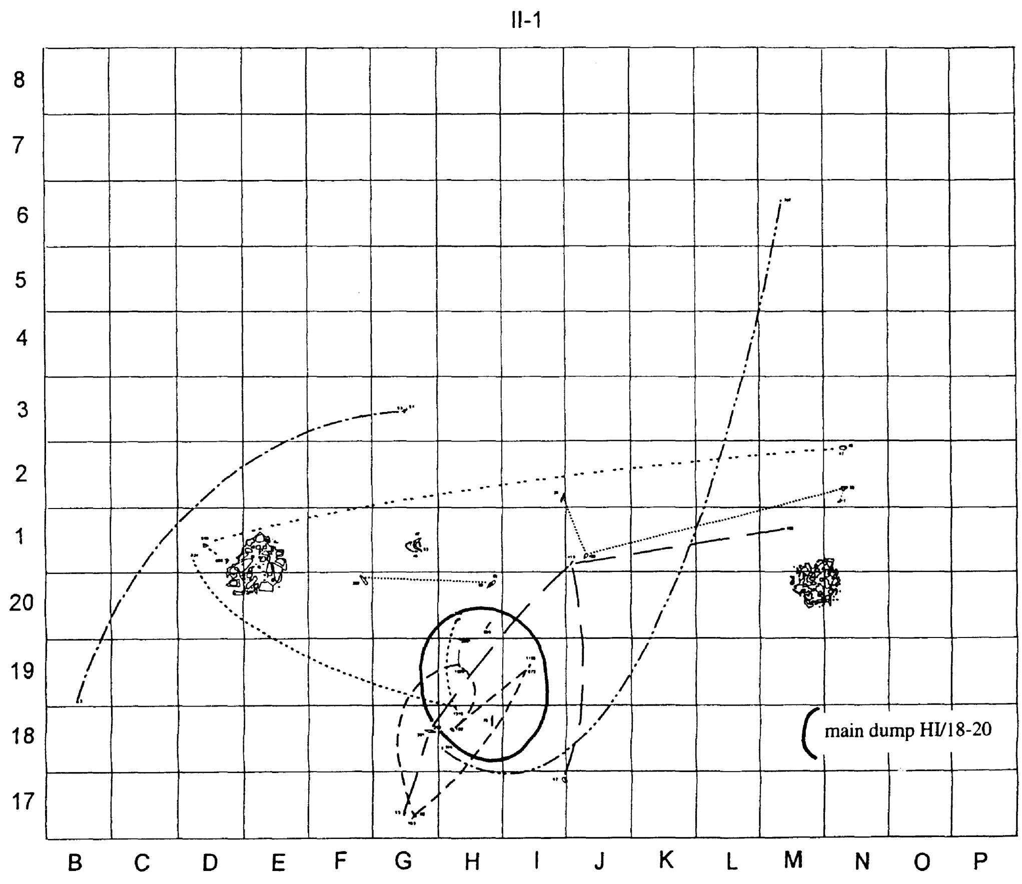

Figure 3 Refits between forelimb elements of eight different individual reindeer skeletons scattered between and around the two hearths (DI and M20) in level II.1.

areas. This pattern contrasts strongly with the reciprocal food sharing evident at the residential campsite of Pincevent (Enloe 1992), strengthening the functional identification of Verberie as a hunting camp.

Conclusion

Verberie is not Pompeii, but it is nonetheless a high resolution archaeological site with great integrity in patterning in artefactual content and configuration, which offers great promise for the interpretation of prehistoric behavior. The problem and the potential trap of dealing with high resolution sites is twofold. First, we cannot allow the excitement or hubris at the luck of our finding such sites to override our prudence in their interpretation. We must use such archaeological opportunities to evaluate rather than to assume the degree to which high resolution can aid us in the interpretive tasks. This is a methodological challenge: to define the limitations set by varying degrees of resolution among different classes of data. Statistical and geological studies are helping us investigate site formation processes in more and more sophisticated fashions. Second, we must develop more stringent experimental and ethnoarchaeological research to enable soundly based inferences from the more intact patterning that high resolution sites can offer. Both of these conditions must be met before we begin telling stories about the past.

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High resolution Neanderthals? Interpreting Middle Palaeolithic intrasite spatial data

P. B. Pettitt

Abstract

Palaeolithic archaeologists have for some time been concerned with high resolution data, which is usually taken to mean intra-site spatial patterning. This paper examines cases of such high resolution for the Middle Palaeolithic, and assesses exactly what such 'flagship' sites reveal about Neanderthal behaviour. Although such cases are rare, and most Middle Palaeolithic sites are just as informative albeit of lower resolution, an attempt is made to interpret what patterning is available. It can be explained by recourse to nothing more that simple human biomechanics, and, in enclosed sites, displays a simple spatial organization that does not differ from that of non-human carnivores. The degree of repetition of such patterning suggests that simple spatial organization was an habitual element of the Neanderthal adaptation.

Keywords

Neanderthals; spatial patterning; behaviour; hearths; butchery.

High definition archaeology: face to face across the millennia?

There has been a trend in Palaeolithic archaeology for some time towards examining the resolution of available datasets. A previous volume of *World Archaeology* (12(2) 1980) demonstrates this clearly, drawing together diverse examples of some *precise moments in remote time*. The rationale was to make showpieces of 'those occasions when archaeological evidence of exceptional quality brings us face to face with other human beings across tens, hundreds or even thousands of millennia' (Roe 1980: 107). Wenban-Smith (1996) has emphasized that such high resolution windows into Palaeolithic worlds have always been viewed as the holy grail of Palaeolithic archaeology: rare combinations of activity, favourable deposition and burial which 'cause them to shine out like planets in the twilight' (Roe 1980: 107). After all, who can deny the immediacy conveyed by the

World Archaeology Vol. 29(2): 208–224 *High Definition Archaeology*

Laetoli footprints, irrespective of their academic importance? The current emphasis in Britain on Boxgrove as an exemplar of high quality information-return demonstrates that this view is still with us, despite well-argued reminders that the bulk of Palaeolithic sites – those in secondary contexts such as in river gravels – have often been just as informative as the high resolution 'flagship' sites, depending on what information one seeks from them (Gamble 1996). The scope of this paper falls within the Middle Palaeolithic and has the simple objective of examining what our resolution of Neanderthal behaviour is and what relatively high resolution data is actually telling us. In doing so it takes a broad temporal view of Neanderthals, i.e. from before the Last Interglacial and down to and including the Châtelperronian, and draws relevant data from western Europe to Ukraine. Many types of data set may be regarded as yielding *relatively* high resolution data. The patterns of raw material movement in the Middle Palaeolithic of south-west France demonstrated by Geneste and others (1985, 1988, 1989; Turq 1989, 1992) and more widely in Europe (e.g. Féblot-Augustins 1993) offer a far higher resolution picture of activity in the landscape than most Lower Palaeolithic sites can offer, and our understanding of the Neanderthal skeleton, physique and biomechanical effects upon it is unparalleled among archaic hominids (e.g. Trinkaus 1989). These may be regarded as high resolution datasets in their own right but, when speaking of high resolution archaeology, archaeologists are usually referring to on-site spatial data. The search for discernible dwelling structures – i.e. a systematic use of space on Palaeolithic sites – is something that attracts archaeologists very much (Stapert 1990). This said, their treatment of such supposed data is often uncritical, and much data can be interpreted in terms of simple biomechanical principles, such as the way humans sit around hearths (Gamble 1986: 263). In keeping with this attraction to on-site data, my paper is restricted to a review of spatial patterning and approaches that have been taken to it in recent years. In this respect it is highly biased, ignoring as it does the large datasets on the wider aspects of technology, subsistence and landscape activity that have been amassed for Neanderthals alone over the last century and more.

Approaching high resolution spatial patterning in Palaeolithic archaeology

Critical studies of on-site spatial data remain limited, and fieldwork is often constructed without spatial models in mind (Gamble 1991). This is surprising, given that archaeological sites are by definition spatial phenomena, i.e. dense clusters of cultural debris (Gamble 1986: 251). But have we been missing the point? Isaac (1981) stressed that such dense patches of materials are only meaningful if viewed in the context of the low density scatter of material in the landscape, and his challenge has been taken up recently by Roebroeks et al. (1992) in a study of the c. 250ka old (Saalian) Site N at Maastricht-Belvédère, Netherlands. Although a small degree of horizontal movement was in evidence at the 'site', the sedimentary character of the matrix, condition of material and degree of refitting indicated that it was in nearly prime context. A large number of the artefacts seem to have been introduced to the locale as individual artefacts, amongst which were tools which had clearly been manufactured elsewhere. Site N may therefore reflect the kind of spatial patterning which one can expect where activities other than

manufacture and maintenance of tools took place, in this case on a number of occasions. It was a place where technology was used, rather than produced, and is an example of what one might suggest was the most common use of space in the Palaeolithic, i.e. simply a point in the landscape, favourable for some reason or other, where hominids paused, carried out a brief activity, and moved on. The study of Roebroeks et al. (1992) serves as a fine example of how low density/high resolution spatial data can be just as informative as high density sites, and has yielded new information as to the 'use' of lithic technology. A contrary view is argued by Cziesla (1990) who suggested that lithic chips and flakes are more suggestive of activity than tools, the distribution of which may simply reflect disposal areas.

Even on sites where the post-depositional disturbance of lithics is minimal and the degree of refitting high, there are a number of problems in the interpretation of the resulting technological and spatial data. For example, at Boxgrove (Austin 1994) and the various Saalian period sites at Maastricht-Belvédère, Netherlands (de Loecker 1992, 1994) it is clear on the basis of incomplete *chaînes opératoires* that material was moved on to the sites in variously reduced forms. Material must have been removed from the sites also, but the distance over which this occurred is unknown. At Boxgrove, there is no evidence for the complete production of a single biface at a single location (Austin 1994: 123). Thus, while many of the knapping scatters appear to be more or less *in situ* and therefore of high resolution, the behavioural context in which they were brought about is still beyond recognition. It is against such limitations that one has to evaluate the usefulness of other *in situ* scatters, such as the apparently seated knapper engaged in the final thinning and shaping of a biface in the lower level assemblage within the laminated silts of Quarry 1 (Austin 1994: 123). High resolution such scatters may be, highly informative they are not.

High resolution spatial patterning in the Middle Palaeolithic

Two decades ago, in a survey of Middle Palaeolithic spatial patterning, de Lumley and Boone (1976) noted that 'our knowledge of the habitat structures of the Neanderthal hunters is still very fragmentary'. This is as true today, although a more critical approach to site formation has resulted in a number of previously supposed habitation structures being eliminated on taphonomic grounds, e.g. the hut at Terra Amata (Villa 1982) or the mammoth bone dwelling at Ariendorf 2 (Bosinski et al. 1995). Unambiguous habitation structures in the Palaeolithic are certainly rare (Stapert 1990: 1). Nevertheless, a number of obvious high resolution traces exist pertaining (probably) to shelters of some form (e.g. Lazaret: de Lumley 1969; Molodova I and V: Chernysh 1965); also, more generally, to butchery (e.g. La Cotte de St Brelade: Scott 1986; Mauran: Farizy et al. 1994; Achenheim: Thévenin and Sainty 1974), and to the use of caves, rockshelters and open air sites with or without hearths. These traces can vary in scale from single hearths with an associated lithic and/or faunal scatter ('bivouacs' in the terminology of de Lumley and Boone: e.g. Hortus bed 33a) to occupational traces possibly left by groups (e.g. Grotte Vaufrey: Rigaud 1988; Les Canalettes: Meignen 1993; Wallertheim: Conard et al. 1995; Pontnewydd: Green 1984).

Structures

The supposed tent-like structure in the interior of the Grotte du Lazaret is well documented (de Lumley 1969) and discussed elsewhere (e.g. Mellars 1996). The point to emphasize here is that activity is restricted to a relatively small area of the cave, suggesting that the occupation was by a small group of Neanderthals only (Mellars 1996: 282). If the interpretation of the distribution of marine shells as representing sleeping areas is correct (de Lumley et al. 1969) then the 'cabin' could represent as few Neanderthals as three. Likewise, the well-known mammoth bone huts/windbreaks/shelters at Molodova I, horizon 4, and Molodova V, horizon II (Chernysh 1965; Klein 1973), could only have 'contained' a small number of individuals. On the basis of the number of hearths within them (15 and 5 respectively), some of which appear to lie within the wall of mammoth bones, they are probably best viewed as indicating numerous occupations of these 'shelters' by similarly small groups. The operative factor was presumably that for as long as these sites remained visible in the landscape they presented the opportunity for shelter, with a minimum of modification each visit, and in this sense functioned in the same way as naturally enclosed cave and rockshelter sites. Similar size/group constraints are also observable in the 'huts' of Châtelperronian level X at Arcy-Sur-Cure (Leroi-Gourhan 1976). Despite the identification of Neanderthal remains in the same horizon, it is unclear whether the huts were created by Neanderthals or anatomically modern humans (Pettitt 1996).

Stapert (1990, 1992) examined spatial patterning which was potentially indicative of habitation structures, using the ring and sector method of recording and analysing spatial data (see also Stapert and Street, this issue). His analysis of archaeological materials in layer 4 of Buhlen (lower site), Germany, supported an interpretation of the patterning as a tent structure (Fiedler and Hilbert 1987). If this is indeed the case, the dimensions of the structure, i.e. as reconstructed from the outermost ring of large stones, were about 5 metres in diameter, which must again reflect a small group size. Numerous hearths, some of which may have been used before the construction of the stone ring, at least attest to use of the location in the usual repeated manner. In this it does not differ from those locations which Stapert dismisses as structures, but sees rather as activities which took place in the open air, i.e. Maastricht-Belvédère site C southern concentration, and Rheindahlen *Westwand* Behausung I.

From the limited structural data, it would seem that palimpsests of Middle Palaeolithic cultural materials were deposited by individuals or small groups in locations that were either culturally or naturally constrained. But how was activity organized in such loci, and what might this reveal about Neanderthal behaviour?

Activity

At Hortus, sometime in the early Last Glacial, a Neanderthal climbed down into the shelter of the fissure, assembled and lit a small hearth, and ate parts of an adult ibex before moving on, possibly after an overnight stay (de Lumley et al. 1972). The remains he or she left behind in bed 33a (Fig. 1) form a characteristic archaeological unit which, when post-depositional disturbance is minimal, appears at many locations in various degrees of

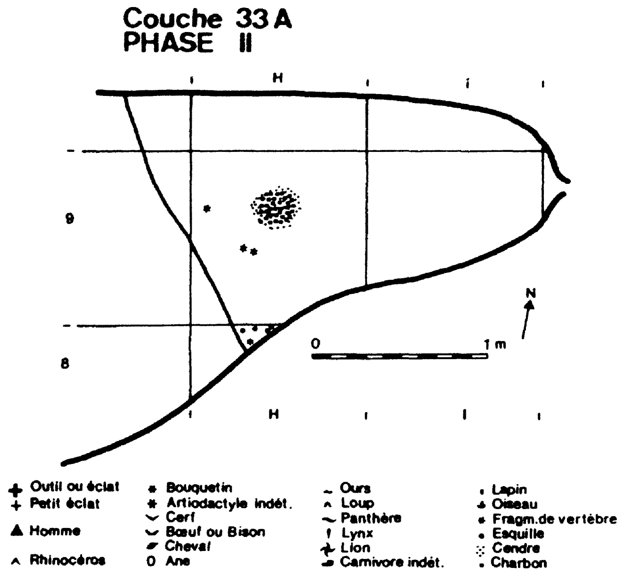

Figure 1 Plan of bed 33a at the Grotte de l'Hortus. Hearth, with scatter of ibex bones (stars) and unretouched flakes (dots). From de Lumley et al. (1972).

palimpsest. Some time later at the same site, another Neanderthal (or perhaps small group) made similar use of the shelter it offered, this time leaving behind the remains of an artiodactyl (species indeterminate) butchered on the spot, together with some bovid and deer remains, amongst a scatter of lithics presumably used in the process of butchery (Fig. 2). The combustion zones formed by palimpsests of hearths need be explained by recourse to no more complex phenomena than these two episodes at Hortus, i.e. short occupations by individuals and/or very small groups, of which there are many other traces at this spatially constrained site. Similar localized activity around hearths has been brought to light in new excavations by C. B. Stringer and R. N. E. Barton at Vanguard Cave, Gibraltar (Plate 1). Here, a palimpsest of hearths was located near to the southern wall of the cave, and a scatter of smashed and cutmarked bones, notably of ibex, and small lithic flakes was positioned at the periphery of these. Given the paucity of lithics, a broken hammerstone – its two halves found about a metre apart – might be interpreted best as being used for smashing the bones to extract marrow, which is demonstrable on many of the faunal remains. Recovery of some burnt bones and burnt fragments of tortoise carapace might indicate some use of the hearths for culinary purposes. In all, the picture is once again of a number of short periods of use of a sheltered section of the cave, probably by a very small group, although more research is needed in order to establish the scale and nature of activity in other sections of the cave.

This basic archaeological unit can be traced at many sites, either in the form of hearth-and-scatter, e.g. at Hauteroche (Débenath 1973), Fontmaure (Pradel 1947), Saint-Césaire (Backer 1993) and Grotte XVI bed C (Rigaud et al. 1995) in France, and Karstein I, Germany (Bosinski et al. 1995), or as an individual's knapping debris, e.g. as at the Last Glacial open site of Hermies, northern France (Masson and Vallin 1996). A more extensive series of individual knapping clusters, which may or may not be contemporary, was found in level D of the early Last Glacial site of Wallertheim, Germany, where a number of blades were produced by a unipolar technique and tools brought on to the site were

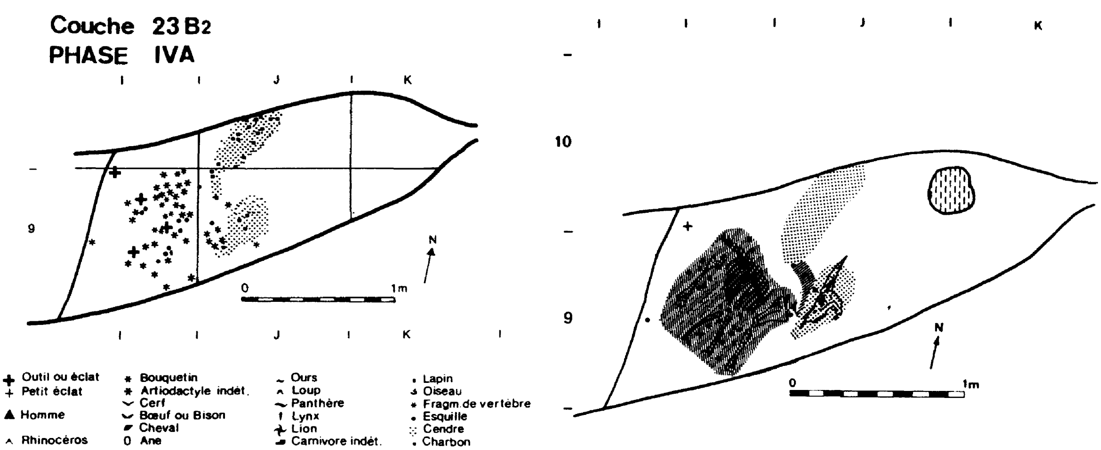

Figure 2 Plan (left) and schematic drawing (right) of bed 23B2 at the Grotte de l'Hortus, showing traces of combustion, artiodactyle butchered in place (stars) and associated lithics (crosses). From de Lumley et al. (1972).

resharpened in the context of small-scale bovid and red deer processing (Conard et al. 1995). By contrast, clear bison processing in level E (Gaudzinski 1992) occurred alongside the deposition of a heterogeneous lithic assemblage in which no refitting was possible, a picture of much lower resolution.

Examples of the spatial segregation of different activities can be found in levels 15, 16 and 17 of Cueva Morín, Spain (Freeman 1978). In each of these levels a regional variant of the Typical Mousterian was deposited as palimpsests in the context of a subsistence strategy based on the acquisition of large herbivores from mainly open but also forest environments and in which access to marine and estuarine resources was apparently common. In levels 15 and 16, scraper-edged lithics were abundant in the cave mouth, whereas sharper slicing forms were most abundant in the interior. One can take this to be indicative at least of a dichotomous spatial organization of tasks into those requiring scrapers, space and light, and those requiring cutting and in which space, light or aerated conditions were perhaps not so important. In level 17 the densest quantity of bones and lithics is located on the side of the cave wall towards the entrance, and once again the bulk of the scraper-edged lithics are found towards the end of the wall nearer the cave mouth. The categories of abandoned lithics tend to be spatially segregated, probably indicating the activity areas of individuals within the broader spatial use of the site. Similar dichotomous spatial patterning is also observable between the two major tool classes in the Châtelperronian at Saint-Césaire – racloirs, which cluster outside the dripline and in an alcove (i.e. on the peripheries); and backed knives, which are most numerous within the shelter, the area from which the Neanderthal skeleton was recovered (Backer 1993).

One of the best studied spatial distributions of Mousterian cave occupation is that of bed VIII of the Grotte Vaufrey, Dordogne, dating to the penultimate glacial (Simek 1988; Rigaud and Geneste 1988). Here, the lack of obvious structural remains led to the search for patterning in cultural debris – *structures latentes* in the terminology of Leroi-Gourhan (Leroi-Gourhan and Brézillon 1972). Cluster analyses demonstrated that the distributions

Plate 1 Vanguard Cave, Gibraltar. Combustion zone (darkened areas in centre of shot) representing palimpsest of small hearths, associated with scatter of butchered ibex and other fauna on periphery (upper left and lower right of trench) and small number of unretouched lithic flakes. (Photo: F. Greenaway, Natural History Museum.)

of bone and lithic scatters were coincident in space, supporting the notion that they were deposited during the same Neanderthal occupation (Simek 1988: 570). Once again, the size of the available area inside the cave and the distribution of cultural materials within it demonstrate that the occupation/s pertained to a small group only. Here, the coincidence in location of carnivore occupation (Binford 1988) and Neanderthal activity (Rigaud and Geneste 1988: 610) is striking, and presumably pertains to the south wall area of the cave, which offered conditions favourable to activity and occupation. Bone fragments, lithic debris and tools fall into three main groups in this area, presumably reflecting the activities of three individuals. It is, of course, impossible to ascertain whether these

scatters were deposited in one occupation or whether they result from multiple, smaller-scale occupations. Each of the three lithic scatters encompasses some 3 metres of space, one of which is physically constrained by large limestone blocks and the wall of the cave itself. The wider distribution of retouched tools compared with débitage is perhaps not surprising and can be sensibly interpreted as reflecting both the difference in location of tool manufacture and tool use areas and perhaps the biomechanics of activities themselves. Some tool types, e.g. denticulates and notches, are mainly located on the peripheries of the main scatters, and racloirs are mainly located on the periphery of the occupation zone in general. This segregation may be interpreted as further reflecting different activity areas inside the cave. The distribution of refitting anatomical elements of processed fauna emphasizes this pattern, in which such refitting groups are spatially distinct from refitting lithic scatters (compare figs 14 and 17 in Rigaud and Geneste 1988). As with other sites which have yielded this resolution of information, the pattern of core activity (knapping) area and periphery (racloirs, bone fragments) is consistent with a generally dichotomized division of space in the cave, on top of which one sees the activities of individuals. Overall, there is a striking distribution of the various categories of material into three individual groups, in which the 'standard' archaeological unit is still visible, especially in scatters 1 and 3 (Fig. 3).

If one can recognize the activities of individuals on high resolution Middle Palaeolithic sites, in the context of a simple degree of spatial organization, can one go any further beyond simple biomechanical explanations? Bar-Yosef (1988) has used on-site spatial

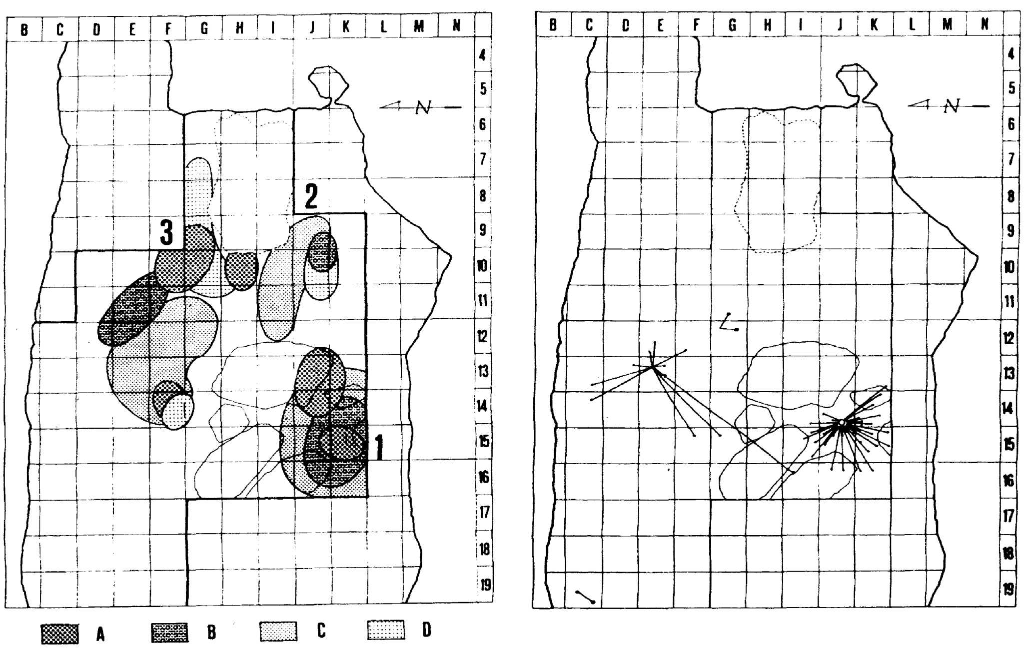

Figure 3 Grotte Vaufrey, Dordogne. Left: distribution of three main activity zones. A) débitage, B) racloirs, C) notches and denticulates, D) combustion zones. Right: distribution of refitting lithics in zones 1 and 3. From Rigaud and Geneste (1988).

data at Kebara Cave, Israel, to infer possible social structure. To do so, of course, requires that the way things are disposed will at least on occasion be determined by social belief. At Kebara, he notes that two Neanderthal babies were deposited in a dumping zone rich in processed faunal remains and débitage, especially in relation to a more central habitation area (see below). By contrast, the adult burial occurred in the centre of this habitation zone, i.e. where the interstratification of hearths was most intensive. Spatially, Kebara also presents another lesson, in that dense interstratification of hearths makes spatial reconstruction of living floors very difficult (Meignen et al. 1982), especially when the resulting ash seems to have been intentionally spread (Bar Yosef et al. 1992: 508). It is apparent from this that only a certain level of activity at a site will leave archaeological residues that are meaningful in spatial terms: too much repeated activity will obscure individual episodes.

At Kebara, the central area, the *décapage*, contained discrete concentrations of bones and lithics (Fig. 4). These are most abundant to the rear of the excavation area and in the area of the north wall: intriguingly, the hearth areas are devoid of bones and poor in lithics. A taphonomic explanation can be discounted, as can one invoking the contribution of carnivores to the bone concentration along the north wall. Perhaps this patterning is most simply explained in terms of the clearing of the main living areas or, once again, through a basic dichotomy of site use into generalized activity areas. Bar-Yosef et al. (1992: 525–6) favour the former, suggesting that it derives from the 'intentional sweeping, tossing, or

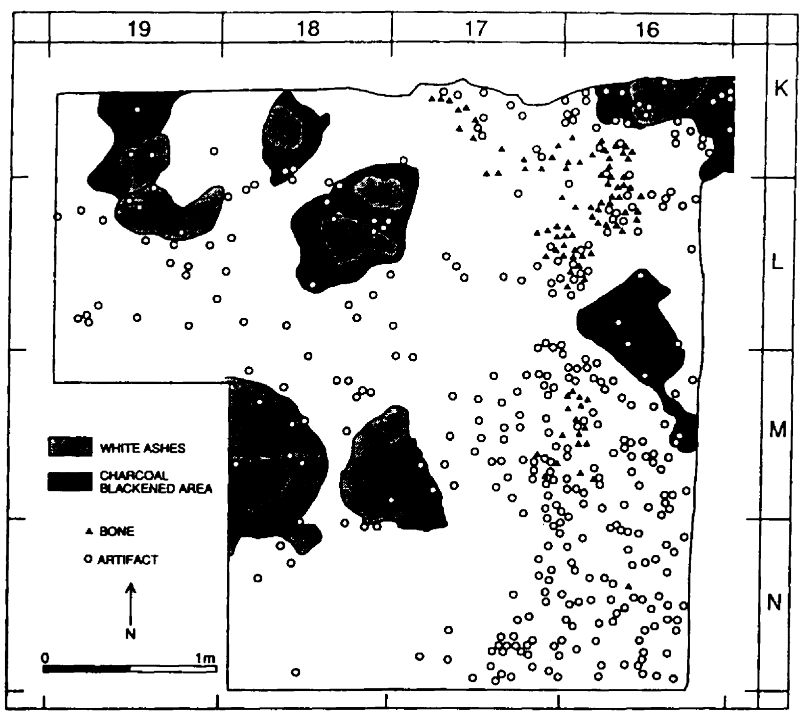

Figure 4 Kebara Cave, Israel. Distribution of hearths, bones and lithics in the Middle Palaeolithic décapage area. From Bar-Yosef et al. (1992).

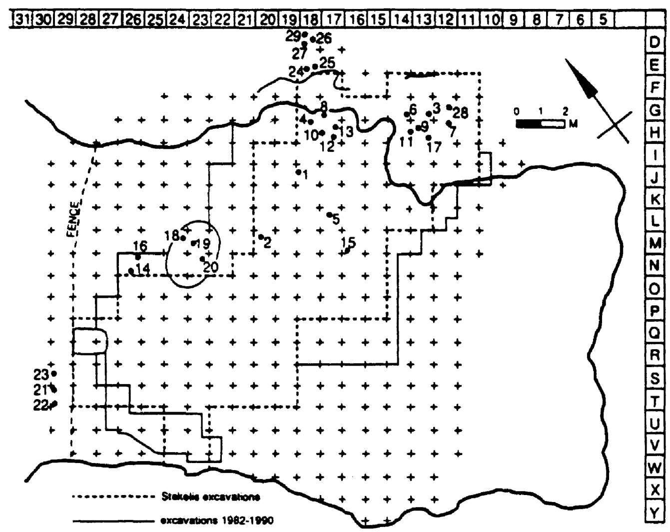

Figure 5 Kebara Cave, Israel. Distribution of human remains in the Middle Palaeolithic levels. From Bar-Yosef et al. (1992).

dumping of trash into this portion of the site'. This notion is supported by the bias towards larger lithic forms in this area, and also cores and cortical waste, materials which one might expect to be tossed away from an activity zone. In terms of the Neanderthal remains found at the site, most of the material belonged to infants and children and was located in the dumping zone of the north wall area (Fig. 5). This includes the KMH 1 infant (7–9 months) skeleton which was either dumped or intentionally buried in this area (Bar-Yosef et al. 1992: 533). Out of this zone, the only burial was that of the KMH 2 adult male, which was placed in the centre of the habitation zone and which, intriguingly, had its head removed in antiquity (ibid.: 527–8). Overall, the authors interpret the spatial data as implying the construction of fires in a well-organized manner and the possibly intentional spreading of ashes perhaps for use as sleeping areas (ibid.: 534). Some degree of basic structuring of space is obviously evident in the definition of a dumping area. To Hole (1992: 537) this in-cave dumping may be a symptom of the relatively short occupation of caves, i.e. the clearance of refuse does not play an important role other than removing it from immediately under one's feet.

The central factor in the perceived use of space by Neanderthals is the hearth or combustion zone. This circumstance is often found, e.g. at the Middle Palaeolithic site of Fara II, Israel, where a number of individual core reduction episodes occurred in discrete patches around a hearth, in the context of a generally unsystematic use of space (Gilead and Fabian 1990). This patterning probably indicates a small number of knappers working in sitting positions and, short of the obvious attraction of the hearth, no explanation other than simple biomechanics need be invoked to explain this high resolution patterning. The most systematic analysis of on-site spatial data using the distribution of material around a hearth is the ring and sector method of Stapert (1990, 1992), noted above. The central assumption with this method is that the hearth was 'a focal point in the daily life of a small group of people' and that, in addition to its obvious functions, it also 'played an important role in social life' (Stapert 1992: 11–12). It is debatable how true this is for

Neanderthal society, but regardless of interpretation the ring and sector method has been instrumental in elaborating aspects of Neanderthal use of space, as discussed below.

Interpreting high resolution Middle Palaeolithic datasets

A number of examples of sites offering high resolution spatial data have been discussed above. What interpretative routes may be taken through them? Before this can be attempted it is necessary to consider other species who contribute faunal material to cave sites.

Non-human carnivores

Although it would seem that hominids and carnivores use caves in different ways, there are similarities at the general level. To a certain degree, ceiling height will determine the location and extent of hominid use of caves, and may in some cases even have constrained maximum group size of occupation, whereas this will not necessarily be the case for other (i.e. smaller) carnivores. Where the spatial loci of non-human carnivore activities has been well studied, both in Pleistocene deposits, e.g. in the Grotta Guattari and Grotta dei Moscerini, Latium (Piperno 1976–7; Stiner 1994: 151) and Rochelot Cave, Charente (Tournepiche 1995), or in the present, e.g. of *Hyaena brunnea* in the Central Namib Desert (Skinner and Van Aarde 1991) and *Crocuta crocuta* in East African caves (Sutcliffe 1970), it seems clear that only certain parts of caves received intensive activity, notably cave mouths and side chambers which were used primarily as defecation zones and corpse processing areas. Other areas were presumably used for denning, and the discovery of complete skeletons of baby hyaenas in such low density denning areas, e.g. as in a burrow in the Queen Elizabeth Country Park, Uganda (Sutcliffe 1970: 1111), supports this notion. This pattern of use leaves a pattern of occupation similar to that of Neanderthals, i.e. in which refuse density is greatest in certain areas only: with hyaenas it is such areas which contain the major accumulations of highly processed faunal debris, e.g. as at the Hyaena den, Wookey (Tratman et al. 1971). Such a pattern of localized concentrations of bones is also present at the open air denning site of Erd, Hungary, where it presumably reflects the denning activities of *Ursus spelaeus* in the early Last Glacial, at another stage of which the channels were also used by Neanderthals (Gábori-Csánk 1968). In these cases, the similarity lies in a dichotomized use of internal space, i.e. into 'living' and 'disposal/processing' zones. For Neanderthals, such latter zones consisted of carcass waste, and seem to have been used for butchery processes, especially those of a heavy duty nature. Such a two-part division of internal space is best explained simply in terms of biomechanics, i.e. that space is needed away from individuals engaged in lighter tasks and rest, for the conduct of heavy duty tasks such as butchery, although other functional reasons might occasionally have prevailed, e.g. the attraction of parasites to refuse piles and carcasses. Whatever the reason for the dichotomous use of space, my point is that high resolution traces of Neanderthal activity are no different from those of other Pleistocene carnivores.

Observation and interpretation

That most Middle Palaeolithic occupation horizons are palimpsests is well understood. However caves and rockshelters fitted into the overall use of landscapes by Neanderthals it would seem that they were occupied by small groups briefly and repeatedly. Where such occupations coincided with good preservation and a low energy of post-depositional activity, and so preserve high resolution spatial data, it is remarkable that the dichotomous pattern noted above exists. What might this mean? The obvious message in such patterning is the degree of *repetition* apparent in the use of different areas of caves for different activities, a factor noted in the Châtelperronian horizon at Saint-Césaire (Backer 1993). In certain cases, the physical character of caves, e.g. the distribution of light/dark, damp/dryness, excrement, ceiling height, etc., may limit the availability of locations suitable for activity, although this cannot be held as a general explanation for all high resolution spatial patterning. Thus, it would seem that the repetition observable in other areas of Neanderthal behaviour, e.g. lithic technology, which has been described as archaic and repetitive (Rolland 1981: 19), is equally observable in their use of space. Where such repetition is observable within the discrete geological horizon, I interpret this as reflecting behaviour that was both limited in variability and *habitual in nature*. This is not confined to enclosed sites only, and is observable, for example, in the bison butchery palimpsest at Mauran (Farizy et al. 1994).

I suggest that, where necessary, such habitual behaviour was organized in simple spatial terms. This essentially entailed the *avoidance* of one area as living space – generally at the periphery of occupation zones – which was used instead for heavy duty (i.e. messy) tasks, refuse accumulation and, one might assume, defecation. In this respect, Neanderthals were no different from the non-human carnivores who often occupied the same caves at different times in the Pleistocene. If the Neanderthals were at all sophisticated social creatures, such sophistication was not played out either in a formalized spatial arena or with symbolic use of material culture.

To summarize, high resolution traces of Neanderthal activity suggest the following:

1 The number of Neanderthal occupants of enclosed sites seems to have been very small. In fact, one cannot eliminate the possibility that all of the high resolution assemblages discussed above were left by a number of *individuals* in the context of solitary occupations.

2 The Neanderthal organization of space, where observable, seems to have been along very simple lines, which cannot be distinguished from that of non-human carnivores. Such two-fold divisions of space, into living and dumping/heavy duty activity zones, is best interpreted in terms both of site constraint and simple biomechanics.

3 The degree of *repetition* of such organization is marked. To some extent this might be dictated by the characteristics of particular sites, but it may also suggest that simple spatial organization was an habitual feature of the Neanderthal adaptation.

4. Superimposed upon this repetitive spatial organization is the basic archaeological unit, which is best interpreted as the refuse of a single individual. Where refitting has allowed the identification of the movement of tool forms away from a knapping scatter, these may be best interpreted as the movement from one activity zone to another, i.e. between the two main spatial areas of a site.

Conclusion: high resolution Neanderthals?

High resolution spatial data pertaining to Neanderthal activity are rare: our understanding of the behaviour of this hominid taxon on the ground is coarse-grained and, given the depositional and post-depositional contexts of most Middle Palaeolithic assemblages, unlikely to improve. This paper represents a broad interpretative approach to a biased dataset of high resolution occupational traces, i.e. those recovered from western Europe.

There are a number of obvious questions we must ask of high resolution archaeology. Of these, the most important must surely be 'does it tell us much at all?' and 'if so, exactly *what* does it tell us?'. In general, high resolution spatial data give us snapshots of individuals in operation, engaged in those simple tasks that archaeologists have recreated in their imaginations since the first recovery of Palaeolithic artefacts. But it is not a holy grail: it has provided little beyond the *illustration* of a limited repertoire of behavioural action. Like all information gleaned from the remote past, resolution is only as good as interpretation: as Wolpoff observed for hominid fossils, high resolution archaeology does not speak for itself.

This paper has represented a simple attempt to interpret spatial patterning left by Neanderthals in western Europe. In this sense it addressed principally the question of exactly *what* it may tell us of the behaviour of an extinct late archaic human. From the observations and interpretations noted above it should be clear that *sophisticated preservation and recovery of archaeology does not necessarily imply a sophistication of behaviour that left it there in the first place.*

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Land-use and site function in Acheulean complexes of the Somme Valley

Alain Tuffreau, Agnès Lamotte and Jean-Luc Marcy

Abstract

Study of the various Acheulean occupations at Cagny has demonstrated the existence of different specialized activities linked with specific geomorphological/locational contexts. These are the collection of raw materials from a chalk talus at La Garenne 2; flake knapping processes and biface manufacture at La Garenne 1; exploitation of large herbivore carcasses beside a channel at L'Epinette; flaking activities and biface manufacture spread out over a large area on the high position of La Ferme de l'Epinette. There was systematic use of territory or landscape, with certain attractive sites leading to the enactment of the same activities in the same places periodically over a time span of several tens of thousand years.

Keywords

Cagny; Acheulean; land use; specialized activities; spatial organization.

Introduction

More than for any other period in prehistory, analysis of archaeological evidence from the Lower and Middle Palaeolithic has been the subject of conflicting interpretations. In East Africa the existence of campsites or occupations linked with 'living' surfaces, and preserving related clusters of faunal remains and stone artefacts, has been claimed from the earliest periods (Isaac 1981). In Europe, too, habitation structures and patterns of spatial organization have been claimed from numerous more recent sites belonging to the Lower and Middle Palaeolithic (Desbrosse and Kozlowski 1994; Lumley and Boone 1976a, 1976b; Yar and Dubois 1996). Such interpretations have often been contested, on grounds of the non-modern character of populations existing before *Homo sapiens sapiens*, of the disturbance caused by taphonomic processes, and methodological errors (Binford 1987a, 1987b; Bordes 1975; Villa 1975–6, 1982). General models established on the basis of ethnography (Binford 1983), or of archaeological observation

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(Leroi-Gourhan and Brézillon 1972), have always been applied most successfully to occupation sites of the Upper Palaeolithic, where preservation of evidence is often good, and where well-defined structures exist (such as built hearth arrangements, pits, or paved surfaces).

Even so, the demonstration of elaborate strategies for acquiring raw materials, and complex arrangements for subsistence (Callow 1986; Geneste 1989; Roebroeks et al. 1988; Patou-Mathys 1993) argues for the existence of spatial organization among Neanderthal populations, both at the level of site and the level of landscape use. Undeniably some sites older than the Upper Palaeolithic preserve clear structures. These have been recognized especially in the context of caves, rockshelters and sites at the bases of cliffs, and are well illustrated by the example of Saint-Germain-des-Vaux, where various types of structures and burnt features have been described (Cliquet 1992).

In relation to open air sites the position is different. Excavations have often taken place in the context of rescue work (motorways, building, high-speed rail links), and have especially involved sites where the high density of remains has justified the costs of field operations. The interpretation of archaeological evidence has been biased by this (Roebroeks 1996) because these sites tend to be the end-result of a palimpsest of separate occupations which it is impossible to characterize individually. For the most part sites which have very large accumulations of stone artefact and faunal remains (level IIa of Biache-Saint-Vaast: Tuffreau and Somme 1988; Mauran: Farizy et al. 1994) can be interpreted to suggest an absence of spatial organization (Farizy 1988–9). This is a misleading impression, for the study of rich sites allows us to extract many lines of information about past subsistence practices related to the activities of stone knapping and butchery (Farizy et al. 1994).

In some cases surfaces with a low density of remains have been excavated over extents of several hundreds of square metres. This gives us an idea of the modalities between occupation areas and background landscape in the Middle Palaeolithic. The lithic material seems to be very sparsely scattered, with a relatively high number of finished tools, and no topographic limits apart from those of the stratigraphic member which contains them (Site N of Maastricht-Belvedere: Roebroeks et al. 1992). This seems to correspond with a picture of artefacts abandoned in the course of journeys occasioned by the activities of resource gathering. There are several instances where the evidence points towards particular activities. At Biache-Saint-Vaast, analysis of the spatial distribution has revealed a zoning which corresponds with various activities (flint knapping, use of flake tools, kill-sites, butchery areas, and consumption of meat), within an uncovered area which covers an extent of several hundred square metres (level II basal, D1 and D2 at Biache-Saint-Vaast: Tuffreau and Marcy 1988). This zonation can be related to an elaborate subsistence package (involving opportunistic hunting of aurochs and rhinoceros, and specialized hunting of bear, not excluding occasional scavenging of other species: Auguste 1995b). It would seem that 'poor' sites, such as those of levels II base, D1 and D at Biache-Saint-Vaast or site K at Maastricht-Belvedere, correspond with activities extending through a fairly short period of time, while the rich sites result from a repetition of these same activities over a long period. It has never been possible to demonstrate the existence of structured habitations comparable with those of the Upper Palaeolithic.

All the information which we possess about the relationships between pre-modern humans and landscape in north-west Europe is derived from sites which are discrete and

cannot be related to one another. Apart from the case of the Vanne Valley – where extensive excavations have been carried out on Middle Palaeolithic sites with low-density lithic remains (Deloze et al. 1994) – studies on the scale of a detailed territorial survey are lacking. The excavations, however, carried out over a period of twenty years at the confluence of the Somme and the Avre, on Acheulean sites situated in a variety of sedimentary contexts, can cast new light on the types of occupations which existed (Tuffreau and Antoine 1995; Tuffreau et al. 1986, 1995, 1997).

Characteristics of the Somme Basin

The stratigraphic and palaeoenvironmental context of Middle Pleistocene human occupations is well known in the Somme Basin because of the historic nature of the research, which has been carried out since the nineteenth century through the work of J. Boucher de Perthes and of C. Picard, and then through more recent research (Breuil and Kozlowski 1931–4; Commont 1908, 1909; Mortillet 1872). The palaeoenvironmental evidence in particular has been synthesized through recent excavations. The same is true for the artefacts which are of interest to us, because those from old collections generally come from selective collection in the quarries and pits.

The alluvial deposits are particularly well preserved. They are found in the form of terraces, in a stepped series rising up from the lower sediments (Antoine 1990; Haesaerts and Dupuis 1986). The terrace system of the Somme is made up of a succession of alluvial formations, with levels varying from 5–6 metres to 50–52 metres above the bedrock present under the base of the present-day valley. Ten formations have been recognized in the region of Amiens (Antoine 1994), where they have been given names taken from local topography (IX: Grace, VIII: Saveuse, VII: Renancourt, VI: Freville, V: Garenne; IV: Epinette, III: Argoeuves, II: Montières, I : Etouvie and basal sediment). The terraces are separated from one another by vertical distances of about 5 m, each corresponding to an incision of the chalk substrate.

Each terrace is made up of an alluvial part and a cover of loessic material, separated by erosion surfaces which indicate a hiatus. Each of the distinct alluvial formations, which can reach a breadth of some hundreds of metres and have thicknesses of 4 to 5 metres, is composed of coarse gravels (basal unit) covered by calcareous earths (upper unit).

The gravels in the basal units represent river systems with braided channels separated by gravel bars. The valley slopes, unprotected by vegetation, were strongly eroded by the effects of solifluction and gelifraction. In certain instances where the geomorphological setting has allowed it, as at Cagny-la-Garenne, slope deposits and fluviatile deposits are found interstratified under the basal unit, and close to the talus of the chalk-slope.

According to the palynological evidence (Munaut 1988, 1992), these early deposits found near the chalk talus were laid down during temperate continental climate phases (wooded vegetation with pine, birch and spruce), of early glacial type, separated by cold episodes (steppic); whereas the context of the gravels in the basal units is periglacial, with a harsh climate and scanty vegetation. The calcareous soils of the upper units were deposited during the silting up of the base of the valley. Their botanical and faunal

contents are characteristic of temperate climatic conditions of continental type (Puisségur 1974; Kolfschoten and Moigne in Tuffreau et al. 1995).

Each of the terrace formations traces an interglacial-glacial succession. The chronological sequence of the various formations – of which the oldest (Grace) dates from before the Brunhes-Matuyama palaeomagnetic transition – is established and verified by their relative positions, their palaeontological contents (Auguste 1995a), their covering of *loesses* (Van Vliet-Lanoë 1989), and by several dating methods (ESR, U/TH and magnetostratigraphy: Laurent et al. 1994; amino acid dating: Bates 1993).

In this terrace series it has been possible to place the various human occupation sites into sequence and into a regional stratigraphic framework. Nevertheless, the sedimentary conditions of the fluviatile contexts were the most conducive to the preservation of bone, and they have attracted prehistorians preferentially. In effect, attention has focused on the traces preserved in the valley, at the expense of those which are present on the high-level sites preserved in *loesses*. The excavation of these last has seemed less rewarding because few quarries are sited in these contexts, and because the artefacts are preserved only at low density, as is shown for example by the site at La Ferme de l'Epinette.

Techniques of excavation and data-capture/recording

The excavations began in 1978 with a first exercise at Cagny-Cimetiere (1978–9 and 1993, surface excavated: 220 m^2), then at Cagny-l'Epinette (from 1980, surface excavated 180 m^2), La Garenne 1 (1986–7, surface excavated 50 m^2), La Garenne 2 (from 1993, surface excavated 60 m^2) and La Ferme de l'Epinette (1993–4, surface excavated 2500 m^2). These have been planned research excavations, except at La Ferme de l'Epinette, which was rescue work. That is, they were generally excavations involving several weeks of fieldwork each year (Fig. 1). In these excavations the artefacts come from layers divided into series of sedimentary units, with total thicknesses of about one to two metres, thus ruling out the digging of large areas. In the case of La Garenne 1, this problem was increased because it was an excavation in a strip two metres wide extending for a length of 25m – creating a handicap for any spatial study. In contrast, the rescue excavation of La Ferme de l'Epinette could be carried out over a much greater area. Effectively it was possible to strip off overburden mechanically because of the low density of remains present, in layers which were separated by sterile sediments.

For several years information about the provenance and attributes of the artefacts has been recorded systematically using electronic theodolites, supplemented recently by coverage of digital photographs serving as a basis for planning. The precision of recording allows us to pose new questions about the taphonomy of the archaeological levels and at the same time to make macroscopic and micromorphological studies of the stratigraphy.

The occupation traces in their sedimentary and palaeoclimatic contexts

The Acheulean sites of Cagny are found in different geomorphological contexts (Figs 2 and 3). Cagny-la Garenne occupies a position at the foot of a chalk talus at the limit of

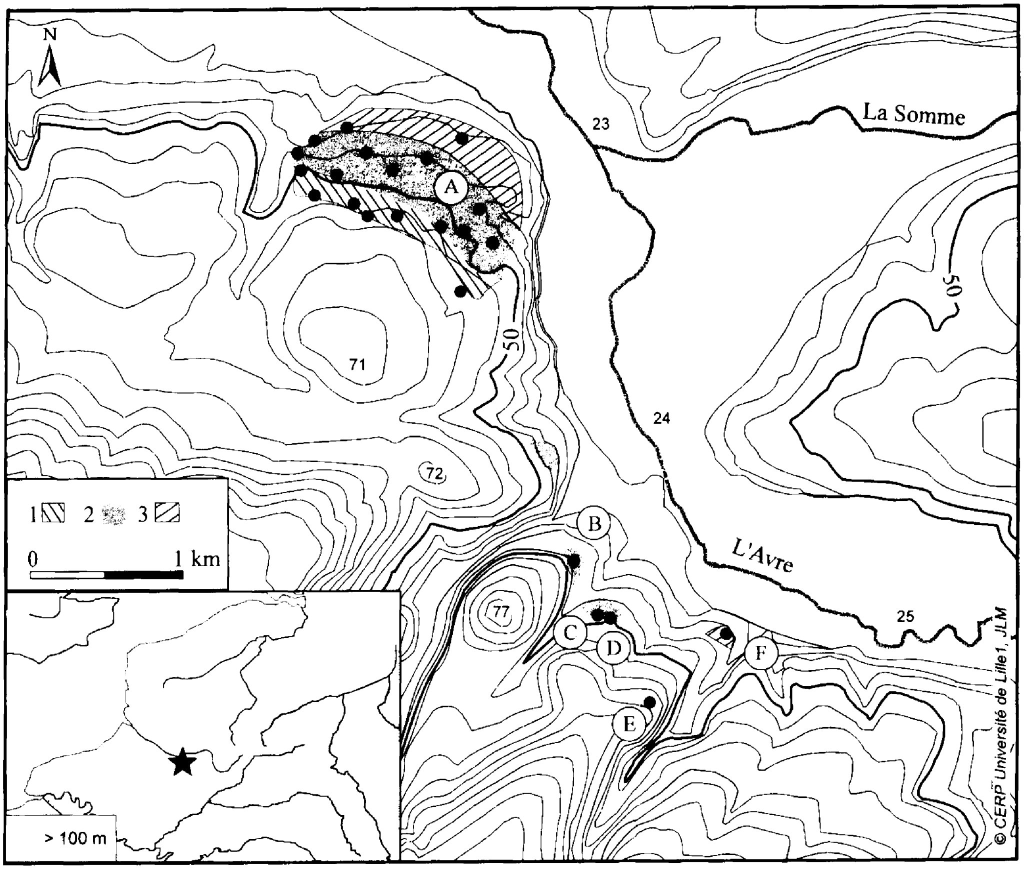

Figure 1 Principal Acheulean sites in the area of Amiens (Saint-Acheul, Cagny). 1: nappe (Formation) de Fréville (+ 35 m); 2: nappe de la Garenne (+27 m); 3: nappe de l'Epinette (+21 m). The distance between contours is 5 metres. A: Saint-Acheul; B: Cagny-Cimetière; C: Cagny-la Garenne 1; D: Cagny-la Garenne 2; E: Cagny-Ferme de l'Epinette; F: Cagny-l'Epinette. After Tuffreau and Antoine (nd).

the alluvial plain. Two other sites are preserved in fluviatile contexts. These are Cagny-l'Epinette (at the edge of a channel running along a chalk talus) and Cagny-Cimetiere (of overbank deposits in the alluvial plain). The last site, Ferme de l'Epinette, is on a hill-slope raised some 30 metres above the alluvial plain of the time, which it overlooks.

Cagny-la Garenne

The position of the sediments of Cagny-la Garenne has allowed the gravels to be attributed to isotope stage 12 (ESR date of 400 +/– 101 ka). The excavations carried out at La Garenne 1 (position of the classic main section) have revealed a sequence composed of fluviatile silts, forming the major element, interstratified with debris derived from the chalk talus about 10 metres away. The fresh state of the flint artefacts contained in the chalky debris (CXCA, CA) shows that these pieces are in primary context. In contrast those coming from the fluviatile silts (LJ, LG) and from a pebbly limestone (CXB) derived

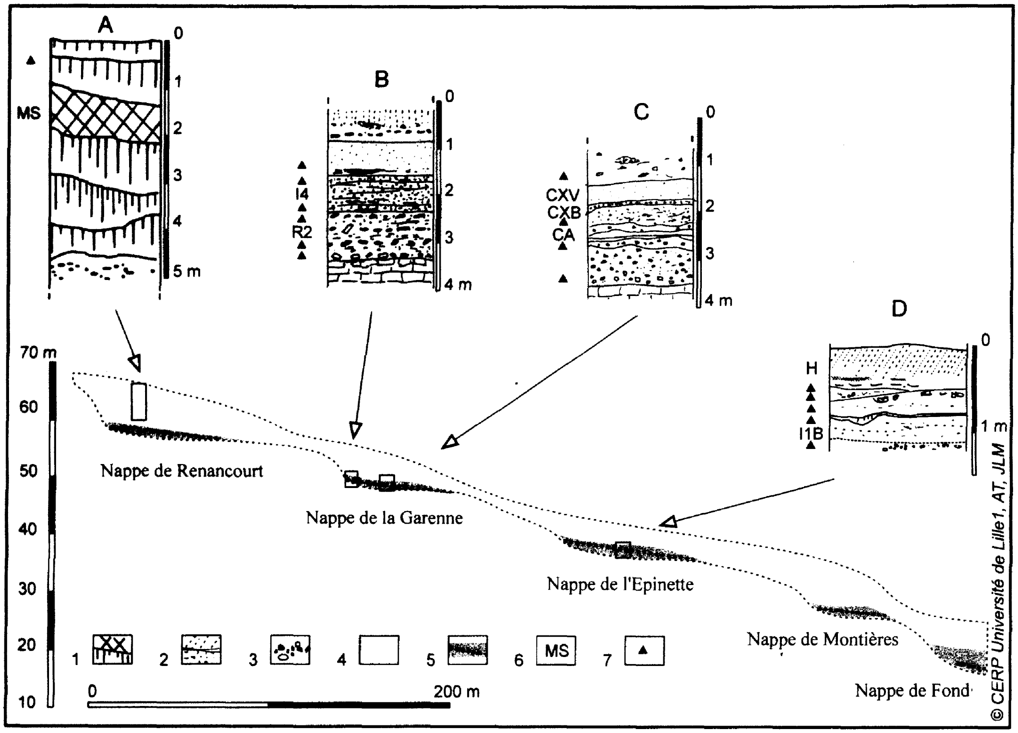

Figure 2 Composite profile of the valley of the Avre (Somme), showing the sedimentary context of the Acheulean levels. A: Cagny-Ferme de l'Epinette; B: Cagny-la Garenne 2; C: Cagny-la Garenne 1; D: Cagny-l'Epinette. 1: cover of silts ; 2: fine-grained fluviatile sediments; 3: coarse-grained fluviatile sediments; 4: hillslope sediments (old and recent loess); 5: fluviatile sediments; 6: archaeological level; 7: further archaeological level. After Tuffreau and Antoine (modified with additions).

from the hillslope, and including gravel and sand in the non-calcareous fraction of the matrix, are sometimes slightly abraded, reflecting the influence of fluviatile dynamics (Antoine and Tuffreau 1993; Tuffreau 1989). The crests between facets of the flint artefacts are clearly abraded in the coarse non-calcareous gravels (CXV) which were laid down in a periglacial fluviatile context (braided river channel). Bone fragments are rare in La Garenne 1 and La Garenne 2, which cannot be a consequence of poor chemical preservation conditions, in view of the high calcareous component in the sediments.

La Garenne 1 has yielded an abundance of archaeological material. Only a part of the lithic material has been studied so far. It is characterized by a high proportion of debitage elements (55 to 88.8 per cent of the assemblage), including flakes from biface manufacture, flake tools (7.8 to 22.5 per cent) which are predominantly notches, followed by denticulates; and by a rather high percentage of bifaces (2.7 to 7.6 per cent: cf. Lamotte 1994, 1995). The majority of the bifaces are elongate forms. There is a high proportion of roughouts and of pieces with cortical butts or sides. It is often possible to work out the form of nodule or blank from which the biface has been made. Some of the elongate bifaces have edges which have been given a regular shape through the removal of small retouching flakes. Some bifaces are clearly distinguished from the rest by their ovate form

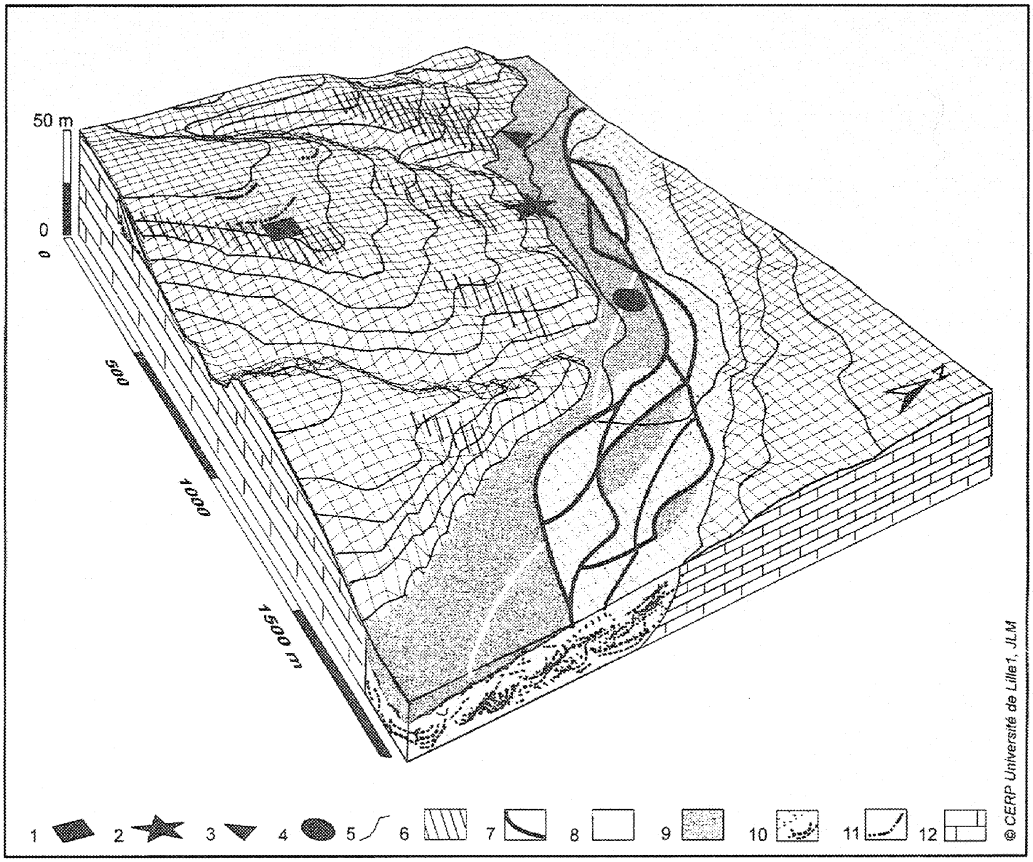

Figure 3 Block diagram showing the types of of topographic/geomorphological contexts of Acheulean localities found in the Cagny sector of the Somme valley. 1: high position with outlook over valley (Cagny-Ferme de l'Epinette); 2: base of chalk talus at end of alluvial plain (Cagny-la Garenne); 3: alluvial plain (Cagny-Cimetière), 4: bordure de chenal (Cagny-l'Epinette); 5: contours, vertical separation 5 metres; 6: areas of loess cover; 7: active river channel; 8: ancient channel; 9: fine-grained fluviatile sediments; 10: coarse-grained fluviatile sediments; 11: exposures of old coarse-grained fluviatile formations; 12: chalk exposed without loess cover.

(oval or limandes). The cores (1.8 to 8.8 per cent) include some Levallois forms in the series CXB and CXV. Some bifaces were turned into cores, preserving one large flake scar, and showing all the characteristics of a technique of Levallois production (preparation of a striking platform, associated with a face of the biface which has been used for releasing debitage, and having lateral and distal convexities comparable with those of a Levallois surface, cf. Boëda 1994). This seems to show that there is a conceptual link between the manufacture of bifaces and Levallois working (Tuffreau 1995). The presence of some choppers and chopping tools should also be mentioned (1.6 to 1.9 per cent).

The name La Garenne 2 designates a sector about 100 metres from the main section, where gravels of the fluviatile sequence are banked up directly against the chalk talus, which is covered by the calcareous fluviatile silts of the upper member. Four levels of large flint clasts (R1, R2, R3 and KR) separated by beds of calcareous silts are present in the

lower part of the gravels (sedimentary units K and L). These beds of large flint nodules correspond to a time when the chalk talus was undercut during an episode of periglacial creep. They were emplaced on the level across the gravel bars of a braided channel, without significant transport, as is shown by the surface state of their cortex, which is not abraded (B. Van-Vliet-Lanoë, pers. comm.).

These levels have yielded pieces showing signs of human activity (R2: 7.65 artefacts per m^2), but their composition is strikingly different from that found in La Garenne 1. Flint nodules which have been 'tested' – that is, showing evidence of one to three flake removals – are very abundant (21 to 32.7 per cent), much more so than cores (3 to 6.4 per cent). Metrical analysis of the tested nodules, in comparison with the natural population, shows that there had been a clear selection for the longest and broadest pieces. Thus pieces with length greater than 180 mm amount to one-fifth of the tested nodules, but only one in twenty of unmodified nodules. Products of debitage are less well represented than at La Garenne 1 (40 to 49 per cent). Flake tools (3.3 to 9.9 per cent) are always less frequent than chopper and chopping tools (6.4 to 12.7 per cent). Bifaces are absent or very rare.

Cagny l'Epinette

The archaeological levels of Cagny l'Epinette are found in fine-grained fluviatile sediments (upper unit of the alluvial deposits) which have silted up a channel in climatic conditions which pass from lateglacial type to interglacial. They can be recognized only through the distributions of worked flints and bone fragments present in the various lithostratigraphic units (for example, H, with 10.2 worked flint and two bone fragments to the square metre on average). This fine-grained fluviatile sequence can be attributed to isotope stage 9 (ESR date of 296 +/– 53 ka: see Laurent et al. 1994), agreeing with its position in the Somme terrace system and with the character of the large mammal assemblage, notably the cervids and equids (*Equus caballus mosbachensis*) (Moigne in Tuffreau et al. 1995). In contrast, the micromammals would suggest a rather more recent age (van Kolfschoten in Tuffreau et al. 1995).

The lower part of the channel filling (Layer I1) includes coarse-grained material (pebbles and abraded flint nodules) originating in the channel banks, or from the erosion of gravel domes protruding above the surface of the basal unit of sediments, which at this time would have been the alluvial plain (Antoine and Tuffreau 1993). The worked flints (I1) include a considerable number of pieces with abraded edges which are clearly in secondary position. At the side, on the edge of the channel, I1 divides into two sub-layers (I1A and I1B), and here the majority of artefacts are unpatinated and unabraded. It has been possible to make several refits in this area. The upper part of the fine-grained fluviatile sedimentation shows the development of a soil overlying a calcitic substrate, which indicates pedogenesis in a regime of temperate climate. At the top comes a covering of sands and silts which were laid in a context of early glacial type (Munaut 1988). In their base artefacts have been found in very fresh condition (Layer H). The series of lithic assemblages at Cagny l'Epinette is characterized by a high percentage of flake tools, among which notches and denticulates are the most common. There is a small number of bifaces, usually preserving cortical butts, and a very low proportion of cores in relation to the number of debitage products (Dibble and Lamotte in Tuffreau et al. 1995).

Most of the bones of large herbivores found in the fine-grained fluviatile sequence (I1,I,I0), as well as those of H, belong to bovids (*Bos primigenius*), especially young animals, followed by deer, which are represented by numerous cast antlers, and by equids. The surfaces of some bones show marks which can be attributed to fluviatile transport, or to human modification, depending on the example. The striations on skulls, vertebral protrusions and ribs relate to the defleshing of carcasses; very broad marks occurring at the proximal end of metapodials of deer and aurochs are interpreted as relating to the severing of the tendons which extend the foot. A proportion of the metapodials, femurs, tibias and radiuses exhibit longitudinal fracture, with evidence of percussion similar to that found at Caune de l'Arago and at Orgnac 3 (Moigne in Tuffreau et al. 1995). Signs of carnivore activity are rare on the bones.

Cagny-Cimetière

The site of Cagny-Cimetière occupies a more central position in the terrace of La Garenne, i.e. further away from the hillslope and in the alluvial plain. Coarse gravels deposited in periglacial conditions, equivalent to the upper part of of the basal unit of la Garenne (CXV), are covered by sands and bedded silts. These last correspond to phases of accumulation of the alluvial plain in temperate conditions (isotope stage 11) in a wooded-steppe landscape. Faunal remains of large herbivores, notably equids, are present in the fluviatile sequence, which also includes some flint artefacts. The density of the lithic and faunal remains is about 0.4 per square metre for both categories.

Ferme de l'Epinette

The main archaeological level of the Ferme de l'Epinette site (Site MS: 0.44 pieces per square metre) is contained in a silty-sandy colluvial covering overlying the fluviatile formations which belong to the Renancourt phase (isotope stage 15–16). The position of these silts and their characteristics allow interpretation as a grey forest soil of initial glacial type, attributable to the beginning of the fourth glacial cycle from present (beginning of isotope stage 10): that is, an age falling between the archaeological sequences of Cagny-la Garenne and Cagny-l'Epinette (on the basis of a stratigraphic study by P. Antoine). At the time when level MS was occupied, the site was in a terrace-position overlooking the valley from a height of some 30 metres, and delimited to the east by a tributary valley cutting the valley slope. Nearby there was chalk talus on the edge of the old alluvial covering, also present at Ferme de l'Epinette. This talus was partially concealed by relics of sands and gravels coming from a very old fluviatile horizon higher up the valley slope (Tuffreau et al. 1997).

The lithic assemblages from level MS include mainly debitage products (82.2 per cent), a fairly high proportion of cores (5.3 per cent), with flake tools more numerous (7.8 per cent) than the heavy-duty component (4.3 per cent) which includes bifaces and some chopping tools. Apart from a biface made of an exotic flint, the raw material consists of flint nodules obtained from the patches of reworked alluvial sediment covering the chalk talus as a veneer near to the excavated surface. Slightly more than 20 per cent of the cores are the result of a method of Levallois flaking aimed at producing a particular flake. The

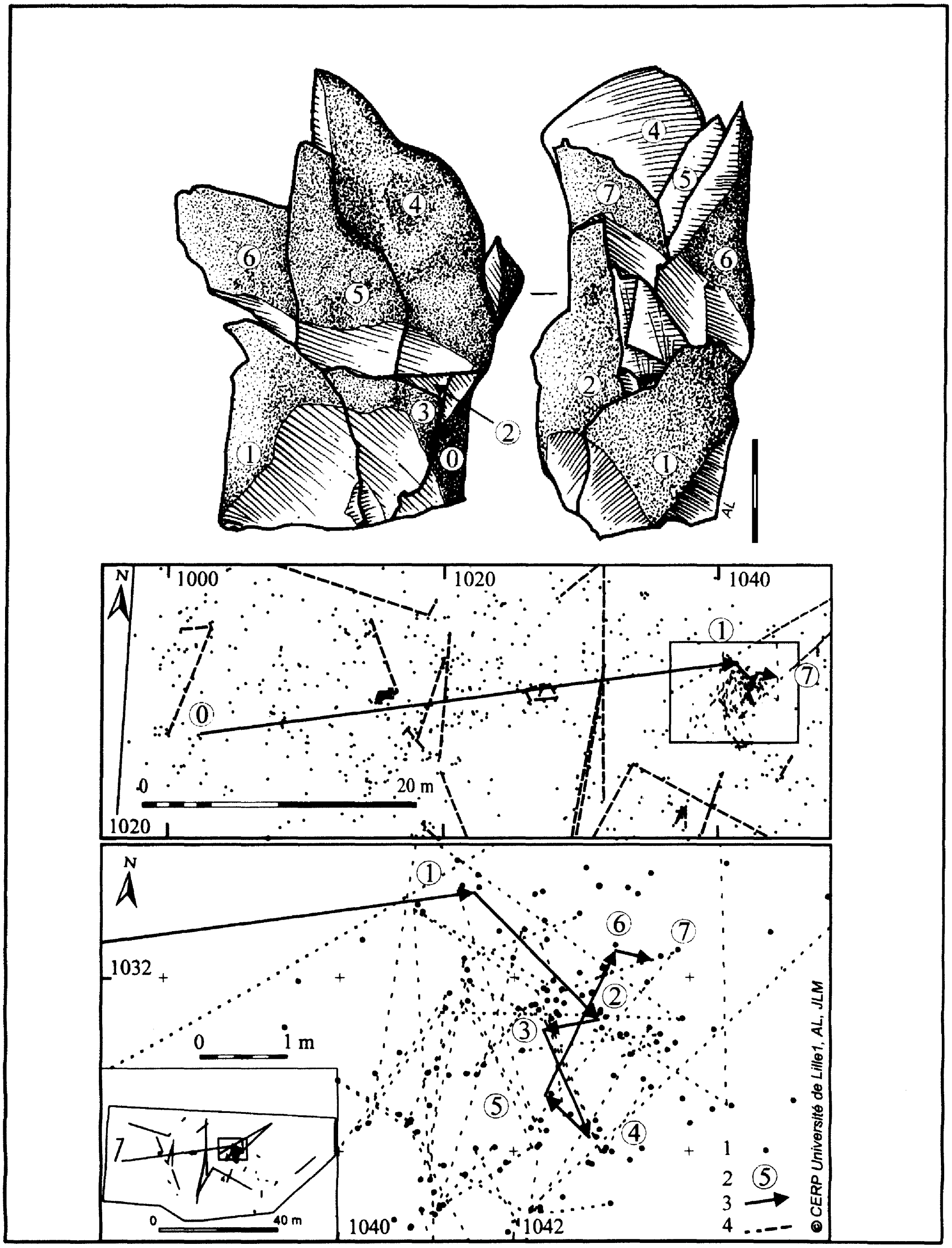

Figure 4 Cagny, Ferme de l'Epinette, MS series: plan of the refits in the group AA. 1: worked flints; 2: the sequence of reduction; 3: refits; 4: further refitting pieces.

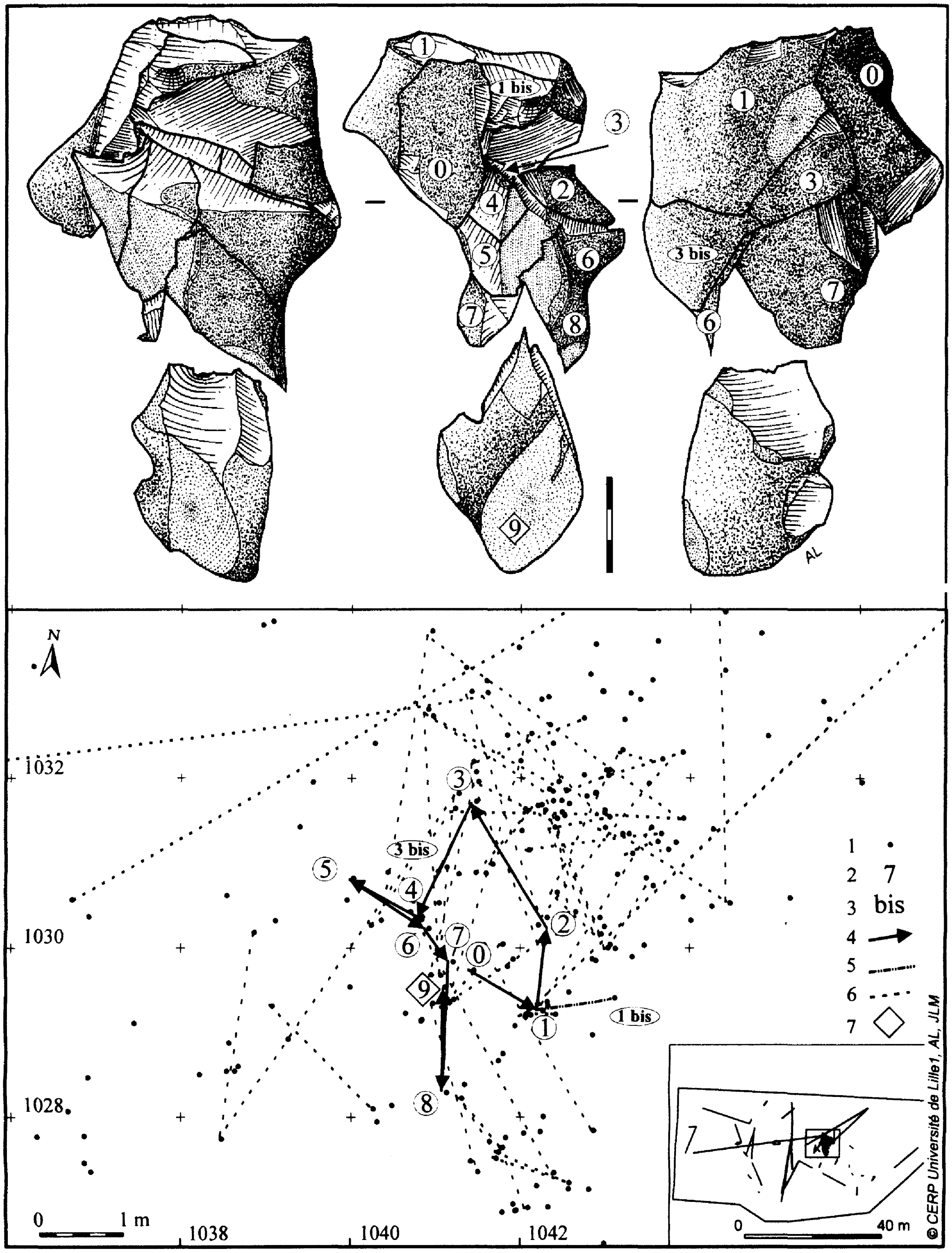

Figure 5 Cagny, Ferme de l'Epinette, MS series: plan of the refits in the group AB. 1: worked flint; 2: the sequence of reduction; 3: connection associated with a flake-removal; 4: refits; 5: raccord; 6: refits in other groups; 7: chopping-tool.

distinctive nature of this toolkit lies in the presence together of chopping-tools and abundant denticulates, and to a lesser degree scrapers made by denticulation. The bifaces are varied in morphology: limandes, ovates, lanceolate and non-classic specimens. Biface trimming flakes and roughouts confirm that these specimens were made on site. All the same, the only refits relating to the bifaces are thin biface trimming flakes with no cortex, suggesting that the earlier stage of manufacture did not take place within the excavated area. Many of the bifaces were used on site, as is shown by the discovery of many broken biface points, and by frequent removals of tranchet flakes, which in some cases represent rejuvenations (Lamotte unpublished).

Refits are numerous, amounting to about 14.8 per cent of all pieces, with forty-eight groups of conjoins including up to eleven flakes with or without the cores themselves. These groups are distributed over the whole of the excavated surface, and bring together a variety of formal categories including flakes, biface tips, cores, chopping tool and flake tools. This said, the majority of both artefacts and refits are concentrated in a sector of about 30 square metres, although it has not been possible to recognize a pattern indicating that one knapper was seated on the surface, as at Boxgrove (Bergman et al. 1990). The picture is one of refits over small distances, with ranges varying from centimetres up to 2 metres. In the case of group AA, the pattern conforms with this, except for one 'opening' flake. This specimen was found near to the chalk talus where it is covered with the gravels which served as raw material, and refits with the rest of group AA more than 40 metres away, in the densest area of level MS (Fig. 4). The flakes of group AA represent the stripping of the cortex from a nodule of flint. The final stages of debitage took place outside the excavated surface, as the core itself is absent. In the case of group AB, found in the same zone of high density, the refits indicate a nodule of flint which was worked to produce a chopping tool (Fig. 5).

Several other examples provide cases of refitting over long distances, more than 5 metres. The great variation in the direction of refits, especially those over long distances, which run against slope direction, or perpendicular to slope direction, shows that the distribution of pieces is principally due to human activities, without excluding the possibility of some element of natural processes. A pattern of refits with a preferred orientation is a probable indication of significant natural disturbance (Bertran and Texier 1995).

Functions of the different sites

The separate Acheulean sites of Cagny have yielded material with a striking apparent variety. Only one site among them – Cagny-l'Epinette – has preserved numerous faunal remains. At Ferme de l'Epinette these are absent for reasons of preservation, but in the case of Cagny-la Garenne 1 and 2, the low number of faunal specimens cannot be ascribed to taphonomic factors, since there is a high calcareous component in the sediments, and the bones that are present are in a good state of preservation. If we consider only the sites where artefacts are the major component, there is again a techno-typological diversity.

The artefacts from the levels with large flint nodules at Garenne 2, like R2 (Fig. 6), stand out through the high proportion of tested nodules, which are four to six times more numerous than cores. Debitage products are clearly in deficit, and bifaces are very rare. This kind of composition of lithic material shows that levels R1, R2, R3 and KR of

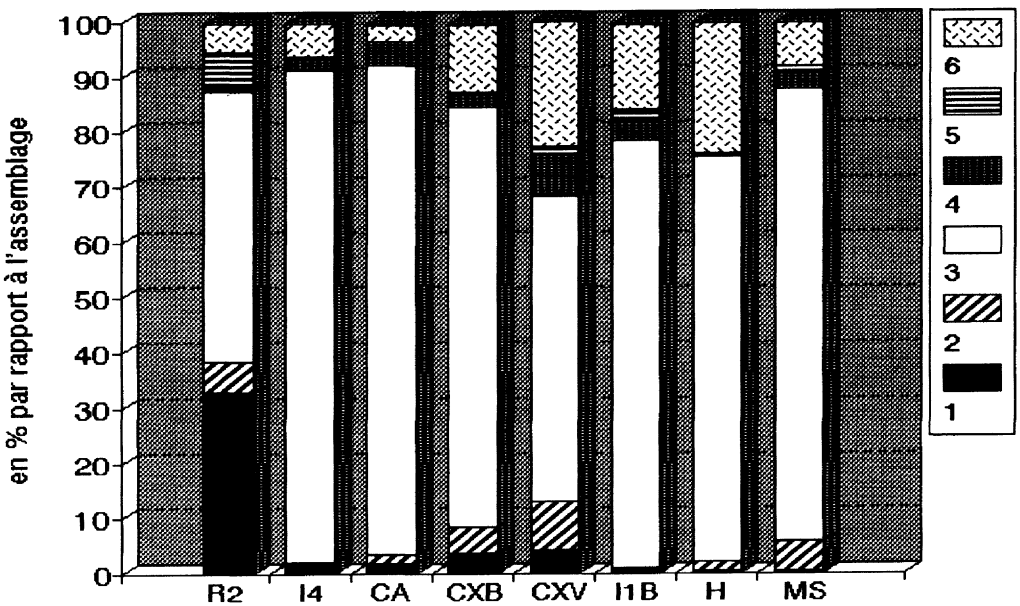

Figure 6 Assemblage composition in the various Acheulean series of the Somme Basin: 1 : tested nodules; 2: cores; 3: products of débitage; 4: bifaces; 5: choppers, chopping-tools, tools on nodules; 6: flake tools. R2: Garenne 2; CA: Garenne 1; I4: Garenne 2; CXV: Garenne 1; H: Cagny l'Epinette; I1B: Cagny l'Epinette; MS: Ferme de l'Epinette.

Garenne 2 represent activities of raw material collection, involving preliminary testing of the natural flint nodules, and export of a large proportion of the debitage products.

At La Garenne 1, there is a clear facies of workshop site involving the manufacture of bifaces and the production of flakes from cores, some demonstrating a mode of Levallois debitage. Other activities also took place, as is shown by the good representation of flake tools in the upper levels (CXB, CXV). The minimal number of faunal remains shows that these activities, although not those of a workshop, are not linked with meat-eating activities.

The distinctive nature of the Cagny-l'Epinette site stems from the presence of numerous fragments of animal bones in the various layers of the fine-grained fluviatile sequence, and from the base of the sandy-silty covering. It is difficult to disentangle the respective roles of different formation factors (natural, scavenging, hunting) accounting for the presence of large mammal bones, but the indubitable presence of evidence of human activity on some specimens shows that animal carcasses were exploited. Further spatial analysis and studies of the lithic and faunal remains from the levels of Cagny l'Epinette, especially level H, should allow us to determine whether this site was used exclusively for specialized activities, occurring periodically, or whether it was instead a kind of base camp – a place where a variety of activities took place, implying a prolonged occupation, in connection with specialized activities which took place elsewhere.

At La Ferme de l'Epinette the presence of a biface of exotic material provides clear evidence that a human group arrived on the site, and began to engage in activities of debitage and tool-making. The refits demonstrate that these activities took place some tens of metres from the raw material source. There is thus a separation between the gathering of

raw material and its use, which took place over an extended area. The archaeological residues of this site thus give the impression of being 'impoverished' in comparison with others, where the high density of remains results from the context of multiple occupations, which took place in a restricted area because of topographic constraints.

La Ferme de l'Epinette also stands out from the other Cagny sites through its high position, which was a feature of the setting at the time of occupation. This is evidence for the mobility of human groups, as demonstrated also by the presence of the biface of exotic flint. In the case of Cagny-Cimetiere, where the density of finds is comparable with La Ferme de l'Epinette, the small area of the excavated surface makes it difficult to work out whether the position in the valley floor had a particular attraction, or whether it is an accumulation of pieces lost in transport.

Conclusion

The study of Acheulean sites in the Somme valley belonging to the middle part of the Middle Pleistocene (*c.* 450–300 ka) shows that they represent systematic exploitation of a landscape or territory, involving different specialized activities. At Garenne 2 this was collection of raw material from a chalk talus; at Garenne 1, a workshop site next to a chalk talus; at Cagny-l'Epinette, exploitation of the carcasses of large herbivores at the side of a channel. These sites were positioned in places with particular topographic/geomorphological characteristics which played a role of attraction. The sedimentary contexts of La Garenne 1 and Cagny-l'Epinette show that the same activities took place at separate moments over a period of several tens of thousands of years, without there being a continuous occupation. A certain mobility in the Acheulean populations is attested by the example of La Ferme de l'Epinette. Here analysis of the lithic assemblages makes plain the existence of complex operational chains (reduction sequences), with spatial disengagement of the different stages – raw material procurement, flake production, biface manufacture, and activities of consumption. Levallois technology was known, and used to a greater or lesser extent. These characteristics – systematic use of a landscape, existence of specialized sites, mobility of human groups, and mastery of complex operational chains – are those which are regarded as established features of the Middle Palaeolithic, which in Europe is linked with Neanderthal populations. It would appear, then, that the evidence left by Acheulean populations does not differ significantly from that of the Middle Palaeolithic, in which behaviour of a very modern aspect can be observed in a number of respects. This means that a separation between a Lower phase and a Middle phase of the Palaeolithic no longer seems justified in western Europe, where first settlement is relatively late compared with the African evidence.

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Observations on the prehistoric social and economic structure of the North American Plateau

Brian Hayden

Abstract

Research at the Keatley Creek site near the Fraser River has provided critical new insights into prehistoric social and economic organization on the Canadian Northwest Plateau. Using a wide range of lithic, faunal, botanical, and chemical analyses, it has been possible to demonstrate that large residential corporate groups exercised privileged access to the best fishing locations and apparently had rights to different mountain regions. These corporate groups maintained these rights as well as their ownership over house locations and specific identities for over a millennium. Large corporate groups were also divided internally into privileged domestic groups and non-privileged domestic groups, probably reflecting hereditary title-holding families and commoners or even slaves. I argue that in order to derive useful information about past social and economic organization, appropriate concepts and questions must be developed from an explicitly archaeological viewpoint rather than a cultural anthropological or sociological perspective.

Keywords

Keatley Creek; households; corporate groups; food resources; salmon fishing.

Introduction

The detailed study of archaeological households and their internal social and economic organization is relatively new to the northwestern part of North America. On the Northwest Coast, there are few examples, including the remarkable 'Pompeii'-like site of Ozette (Samuels 1991), and the detailed excavations of houses undertaken by Ken Ames at the Meier site near Portland, Oregon (Ames et al. 1992), as well as the excavations undertaken by James Chatters (1989) at Sbabadid and Tualdad Altu in Washington State. On the Northwest Plateau, the detailed excavations that I have directed since 1986 at Keatley Creek are notable for focusing on understanding the economic and social organization within the unusually large houses that occur at the site. The prehistoric winter housepit

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site at Keatley Creek is composed of over 115 structural depressions, some of which exceed 20 meters in diameter. This article summarizes the approaches that I and my co-workers have utilized and some of the results. Further discussions can be found in Hayden and Spafford (1993), Hayden et al. (1996), Hayden (1997), and Lepofsky et al. (1996). Final reports are in preparation.

The primary goal of the Fraser River Investigations into Corporate Group Archaeology project was to understand why the unusually large residential corporate groups emerged at Keatley Creek and the other large villages of the Classic Lillooet Culture. I wanted to know why some houses became very large and how they differed in their social and economic characteristics from the smaller, non-corporate households that co-existed at the site. In this article, there is only space to discuss the larger structures. We approached this problem from numerous perspectives, some relatively traditional ones, and some that were more novel.

Approaches to the study

The approach that we have taken is cultural, ecological and materialist. We adopted this approach because ecological and economic factors appeared to constitute the best causal models for reconstructing and understanding the basic aspects of social organization that we sought to recover. However, in order for such an approach to succeed, it is essential to ask the right questions in the right way. Specifically, I suggest that it is necessary to frame questions about past social organization in *archaeologically* meaningful terms – a position also argued by Deetz (1968) and Freeman (1968). In many instances, archaeologists have adopted uncritically the terms, concepts, and theories of social or cognitive anthropologists, or have even used emic standards (i.e. indigenous ideals) against which to measure their interpretations (e.g., Heider 1967). However, archaeological data are different from social and cognitive and emic data, just as they are different from psychoanalytic data and microbiological data. The goals, concepts, and theories of other social sciences are not necessarily appropriate for dealing with archaeological problems and data. I suggest that some of the basic archaeological phenomena related to social organization that are most suited for archaeologists to focus their theoretical attention on are:

- interaction spheres (Hayden and Schulting 1997),
- communities (habitation sites),
- activity groups (specialized sites or activity areas),
- large multifamily residences (residential corporate groups – Hayden and Cannon 1982),
- domestic groups (hearth areas),
- institutions (administrative buildings),
- ritual/feasting groups (temples, shrines, mortuary cults), and
- cemeteries (Chapman 1981; Goldstein 1981).

Archaeologists can trace the variability and evolution of these kinds of phenomena. They can address issues of inequality in these units of organization. Archaeologists can ask meaningful questions about the ecological and other conditions that affect these units.

And archaeologists can create testable models to account for changes of these phenomena.

On the other hand, archaeologists are poorly equipped to deal with many of the questions of individual variability and history, kinship structure, recruitment criteria, descent rules, non-residential corporate groups, normative rules, consciousness, or other cognitive aspects of past cultures. All of these aspects may be of very great interest to social or cognitive anthropologists, and may even be central to the theoretical goals of these disciplines. However, they do not provide useful questions that archaeologists can ask about past societies. More detailed consideration of these questions will lead into a prolonged theoretical discussion. Here it is sufficient to point out that framing questions about past social organization in archaeologically useful terms was an important initial parameter of the research that was undertaken at Keatley Creek. The immediate goal of this article is to present some of the results of this research rather than dwell upon the theoretical foundations. Nevertheless, our results do provide a reasonable example of the kinds of interesting conclusions that can be obtained about social organization when approached from an explicitly archaeological and ecological perspective using rational and nomothetic guidelines.

In terms of overall conclusions, we have been able to demonstrate that the large structures at the Keatley Creek site were residential structures and that the residents of these large structures had access to the highest ranked species of salmon in the region whereas the residents of small structures did not. Control over prime fishing locations probably constituted the economic foundation of the large residential corporate groups. Moreover, there was a fundamental division of internal space in the large residential structures. One half of the domestic space was occupied by elite, title holding members of the residential corporate groups while the other half of the residential space was occupied by client families and probably some slave residents. There is additional evidence that one domestic area was probably occupied by a corporate administrator or 'chief'. Finally, we were able to determine that the largest of the residential corporate groups retained their social and economic coherency and identity for over a millennium before the site was finally abandoned. In the following pages I will examine one large structure in some detail as an example of how these conclusions were established.

Keatley Creek

The Keatley Creek site is located on a dry terrace above the Fraser River near the present day town of Lillooet, on the Interior Plateau of British Columbia, Canada (Fig. 1). The environment is semi-arid with a continental climate, and the terraces are covered with sagebrush, small cacti, and sparse grasses. The mountains that rise abruptly at the back of the site are covered in pine, spruce, and Douglas-fir trees (Plate 1). While game and food plants are not particularly abundant, there are a number of extremely important salmon fishing sites that stretch from the town of Lillooet to the town of Pavilion and beyond. This part of the Fraser River was renowned in early historic times as the most productive salmon fishing area throughout the entire interior drainage of the river. Many surrounding groups came to the Lillooet region to trade for dried salmon surpluses. There is a

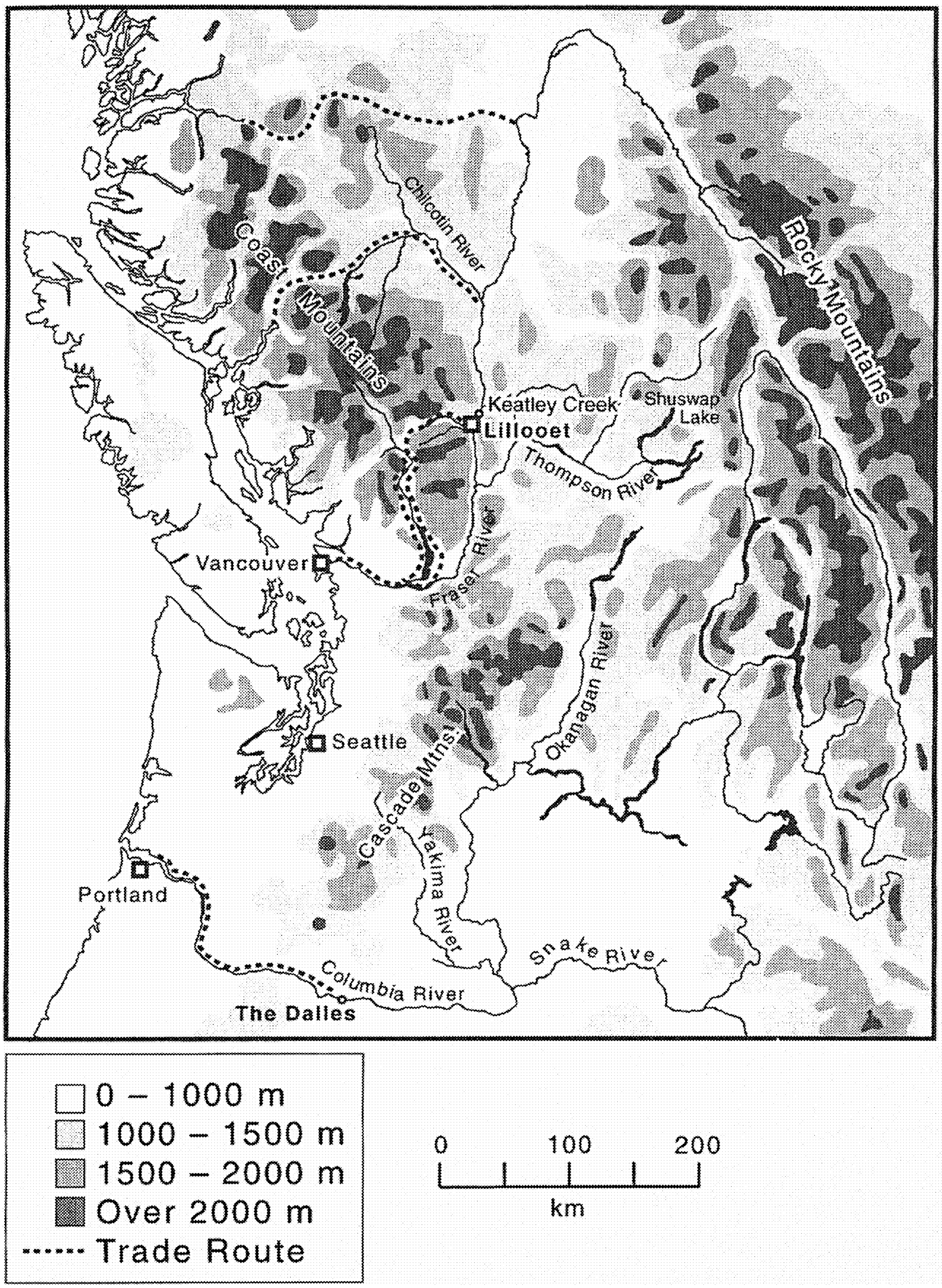


Figure 1 Map showing the Northwest Plateau and Coast of North America and the location of Keatley Creek along the Fraser River (from Hayden 1997)

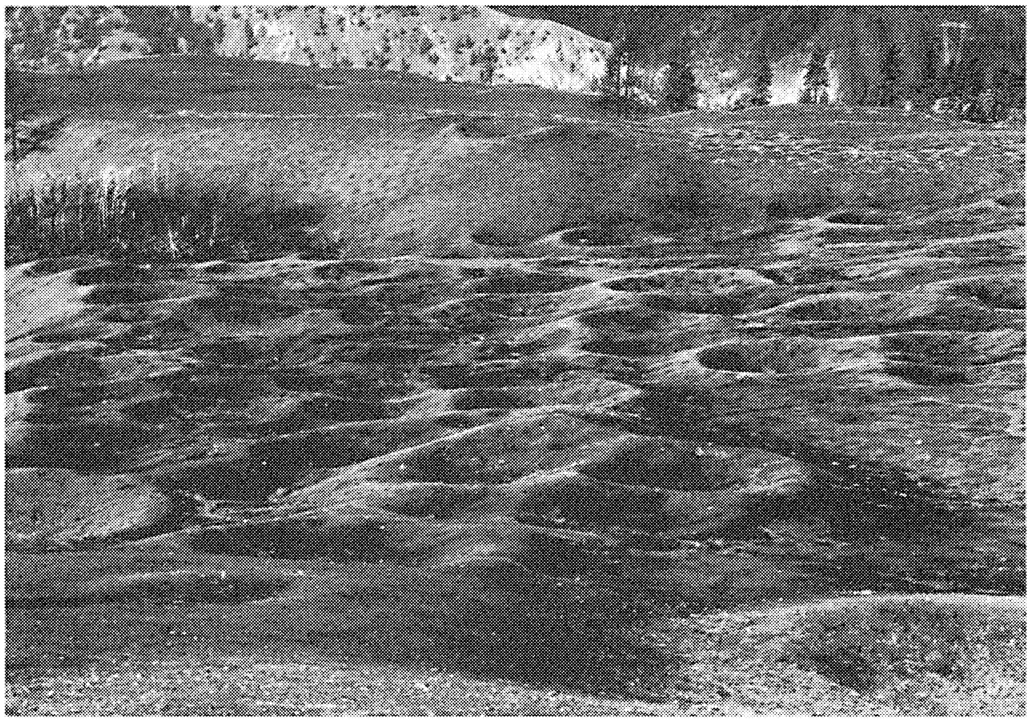


Plate 1 The core of the Keatley Creek site after a brush fire removed surface vegetation. The portion of the site core visible in this photograph is about 200 × 200 meters. The largest house depressions are about 20 m in diameter.

general level of continuity between the Late Prehistoric period cultures (4500–200 BP) and the present ethnographic groups in the region. Most of the very large and medium-sized housepits at Keatley Creek appear to have been initially constructed during the Shuswap Horizon (3500–2400 BP) and to have been abandoned around 1100 BP.

During excavations:

- we recorded the size of all storage pits and hearths;
- we also recorded the depth of fire-reddening beneath the hearths.
- we excavated and screened in natural levels and in 50 cm. units in order to minimize recording time, but maximize provenience information.
- we systematically sampled floor deposits in every square meter for soil chemistry, plant remains, small debitage, and small bone analysis. Samples were floated and wet screened with 1 mm mesh.
- we developed a lithic sourcing program of analysis.
- and finally, because our interpretations ultimately depended on our ability to identify floor deposits accurately during excavations, we developed a series of observations that we thought could be used for distinguishing floor deposits from roof deposits, and then we tested these using faunal and other artifact patterning as well as granulometry.

We subsequently developed detailed site-formation process models.

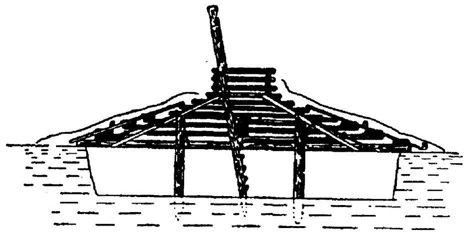
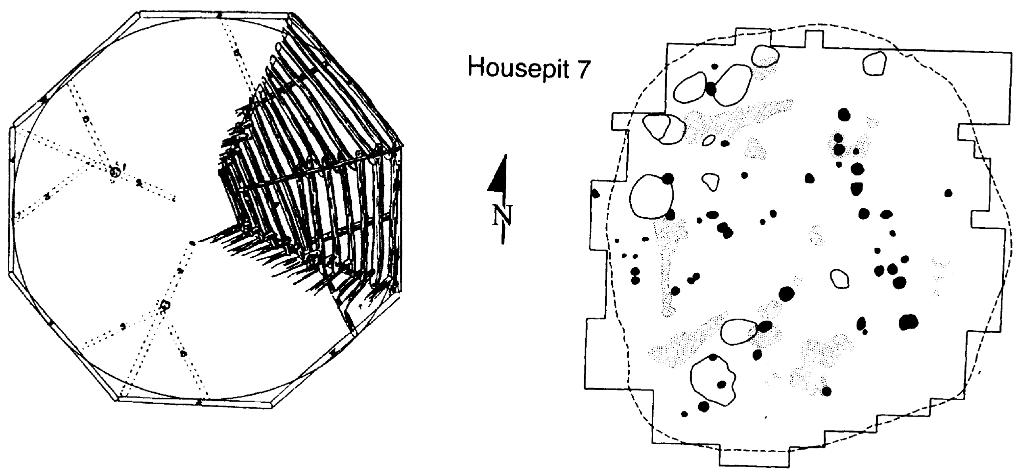


Figure 2 (Left) A schematic nineteenth-century illustration of an earth-covered pithouse with a central ladder descending through the smoke hole (Dawson 1892). (Right) The floor plan of Housepit 7 at Keatley Creek; stippling = hearths, outlines = storage pits, black dots = postholes.



The houses themselves were originally dug into the earth to a depth of about 0.5–2.0 meters. The depressions were roofed over with timber, bark, mats, and grass or conifer needles, with dirt piled on top of the entire roof as described in ethnographic accounts (Fig. 2). The favored entrance was via a log ladder down the central smoke hole; however there are clear instances of some houses having ground-level side entrances. In houses that were occupied over many centuries, refuse accumulated around the periphery of the houses as a 'rim midden' that became stratified over time to varying degrees. Due to the dry climate, preservation of organic materials was excellent in both the floor deposits and the rim midden deposits. Most structures were intentionally burned upon abandonment, creating a convenient charcoal layer on top of the living floors and sealing the living floors with roof collapse, thus enhancing preservation of materials on the floors.

Results

In the 1960s, Arnoud Stryd (1973) had begun a similarly oriented program of excavation in the Lillooet area at one of the other major Classic Lillooet sites only a few kilometers downstream from Keatley Creek. One of his major conclusions was that the large structures at the Classic Lillooet sites were not special function structures, but normal residential structures. Our results amply support Stryd's. Excavation of a large housepit (HP 7)

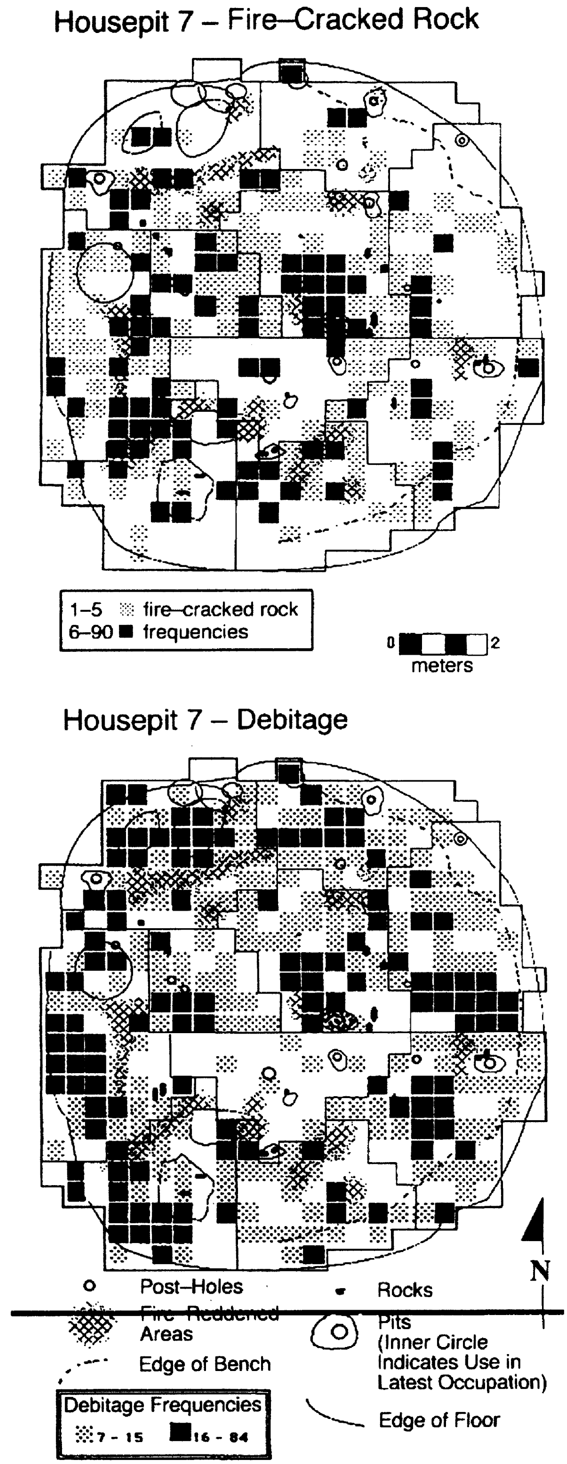


Figure 3 Top: The distribution of fire-cracked rock on the floor of a large housepit (HP 7) clearly concentrates around fire-reddened zones of the floor (these features are more easily visible in Fig. 4). Few fire-cracked rocks occur between the fire-reddened areas of the floor and the wall of the housepit. Bottom: The highest concentrations of debitage also are strongly associated with hearth areas; however, in contrast to fire-cracked rocks, most debitage is concentrated between the hearth areas and the housepit walls, indicating an important division of space around hearths based on specialized activities. Note also that both debitage and fire-cracked rocks are associated with hearths on both the east and west sides of the house floor (from Spafford 1991).

at Keatley Creek demonstrated that there was a series of hearths that formed a concentric ring about 2 meters inside the housepit wall, as one might expect of a series of domestic groups residing along the perimeter of the house. Each of these hearth areas was associated with a concentration of fire-cracked rocks, debitage, and stone tools (Fig. 3), again indicating their essential domestic function. The stone tools associated with each structure and each hearth were fundamentally similar (see Spafford 1991), including predominantly projectile points, scrapers, notches, expedient pressure flaked knives, utilized flakes, abrading stones and stone anvils (probably for cracking bones). The wide range of activities represented is again consistent with domestic functions rather than specialized functions. As yet, we have been unable to identify any household assemblage that departs significantly from this generalized assemblage profile.

There is an interesting complementary distribution of a number of stone tool types within HP 7. Notably, fire-cracked rocks, notches, and bifaces tend to occur on the sides of the hearths closest to the center of the house (Figs 3 and 4), while heavily retouched scrapers, billet flakes, and projectile points tend to occur on the side of the hearths closest to the wall (Spafford 1991; Hayden and Spafford 1993). Analysis of debitage between 1 and 10 mm in size confirms that these concentrations are derived from *in situ* activities rather than storage or sweeping. While this complementary patterning of tool types might be interpreted in terms of sexual division of labor, I suspect that it more closely approximates the different constraints on various types of tasks, with the messier, more space-demanding tasks such as cooking and butchering and spear making occurring in the central sectors of the house where there was more headroom and available space, whereas the more fastidious tasks such as projectile point manufacturing, biface resharpening, tailoring, and tool storage were probably conducted in the comfort of domestic bedding against the walls of the structures.

If we examine the character and distribution of pit features and hearths visible in Figure 4, a number of other patterns become apparent. First, all the large, deeply fire-reddened (up to 8 cm into the sterile till) hearths are on the west half of the house floor while all the small and superficially fire-reddened areas are in the floor center or on the east half of the house floor. Second, a similar patterning can be observed with the storage pits. In fact, the large storage pits all seem to be associated with the large hearths in the western half of the house. The two most plausible explanations for such patterning are either that (1) the differences in hearths and storage pits on the two sides of the house represent different activity areas (e.g., with food preparation and storage taking place on one half of the house while food consumption and/or sleeping took place in the other side of the house), or that (2) the differences between the two sides of the house in hearths and pits represent socioeconomic differences (e.g., with wealthier more powerful families living on one side of the house while poorer families resided on the other side of the house).

Several lines of evidence strongly support the interpretation that both sides of the house were occupied by domestic groups rather than being used as different activity areas. First, the hearths on both sides of the house are associated with fire-cracked rocks, debitage, and similar suites of stone tools including anvils and abraders. Second, analysis of plant remains across the floor by Dana Lepofsky clearly shows that conifer needles and grass seeds concentrate strongly along the wall areas of both sides of the house (Fig. 5). Ethnographically, these materials were used as bedding materials, thus indicating that both sides

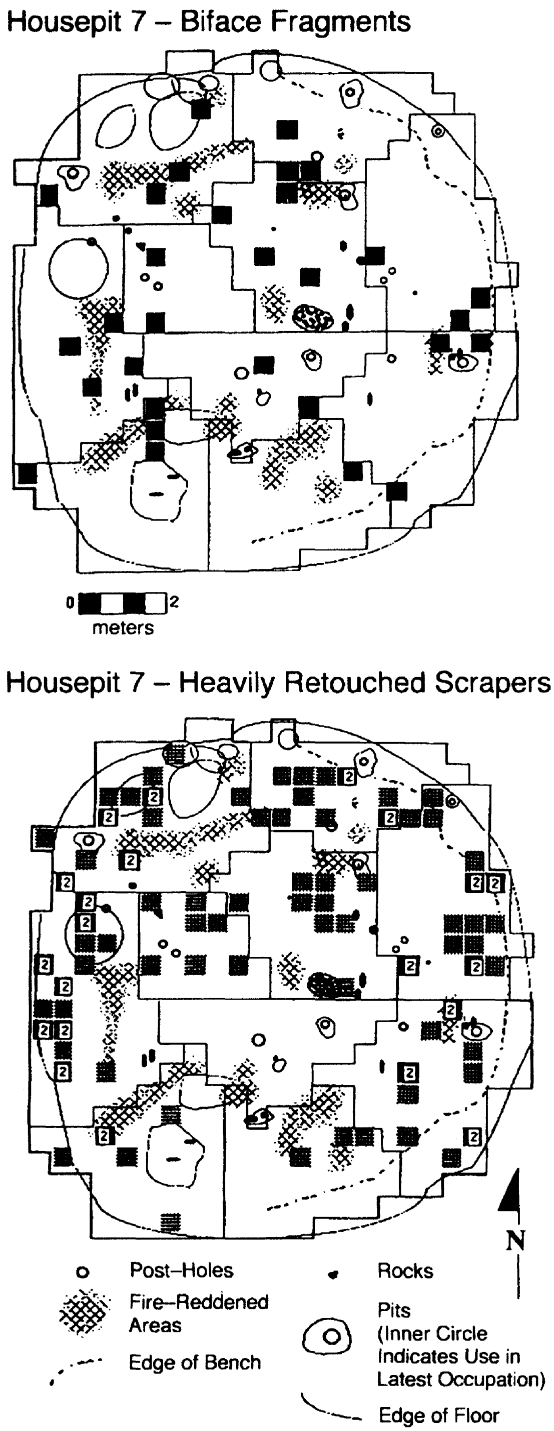


Figure 4 Other tool types also display a complementary distribution around hearths with some, like biface fragments (top), occurring rarely between the hearths and the housepit wall, while others, such as heavily retouched scrapers (bottom), occur predominantly between the hearths and the housepit walls. This reinforces the notion that there was a fundamental division of space around the hearths according to the nature of the activities being performed. Again, the distribution of these, as well as other tool types, indicates that both the east and west halves of the house floor were being used for similar activities. On the other hand, note the substantial differences between the east and west halves of the houses in terms of the occurrence of large storage pits and large, deeply reddened hearths which are most clearly visible at the top of this figure. These differences in such storage and consumption features indicate that there were major differences in material wealth between domestic groups in these houses (from Spafford 1991).

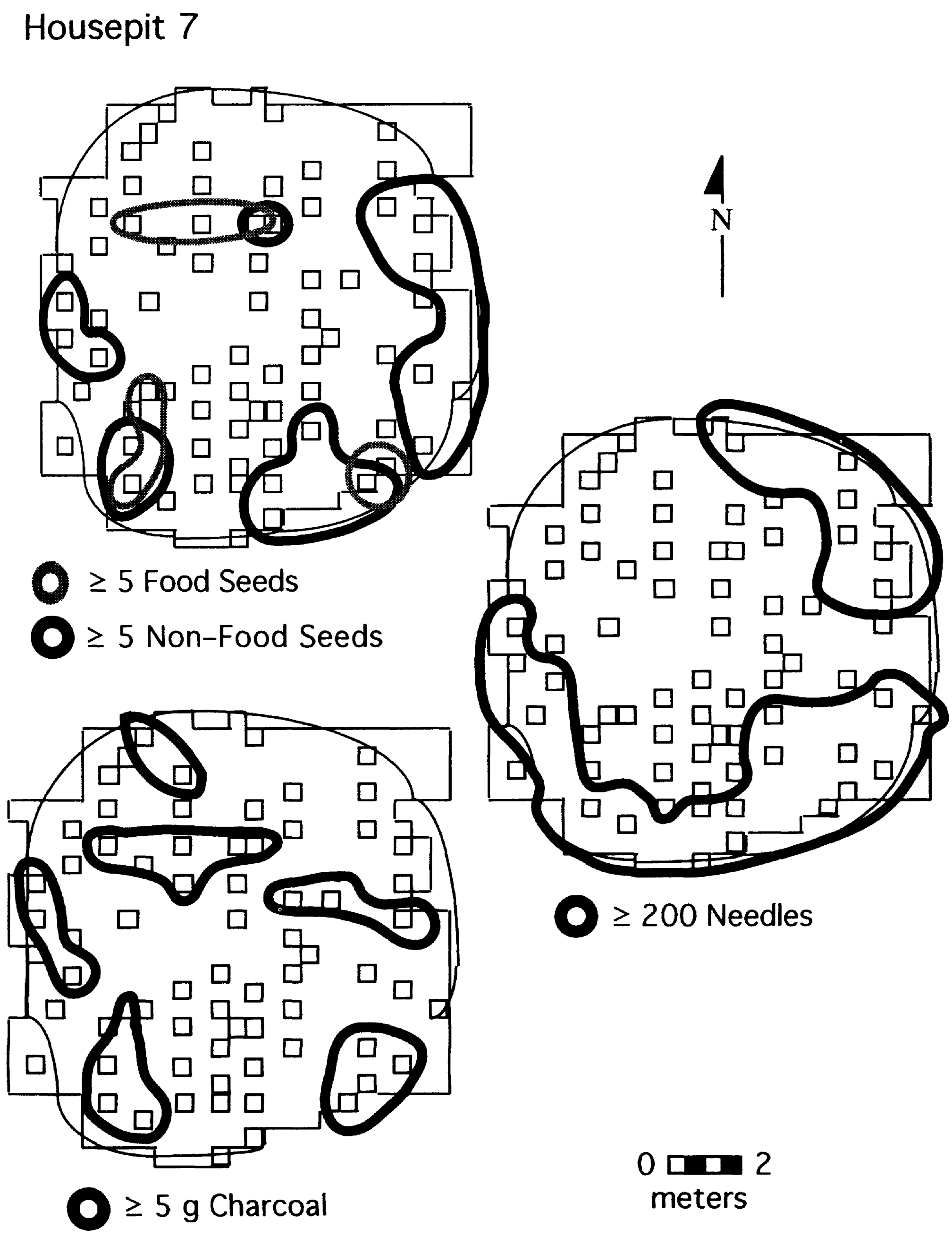


Figure 5 Conifer needles, used for bedding, here display an almost continuous dense distribution around the perimeter of the house floor, where people were reported to have slept ethnographically. Grass was also used for bedding and pillows and the concentration of non-food seeds in these same areas probably reflects the use of dried grasses and weed plants for bedding as well. The high concentrations of charcoals around fire-reddened areas further confirms the relatively intact nature of the floor deposits that we excavated (from Lepofsky et al. 1996).

of the house had bedding along the walls. Third, Bill Middleton has shown that similar concentrations of chemical elements such as phosphorus occur on both sides of the floor (Fig. 6) again indicating that similar, redundant activities were occurring on both sides of the house as would be expected from domestic groups residing around the periphery of the house rather than distinct activities being carried out on the two sides of the house floor. Finally, these results are consistent with the results obtained by Ames and Chatters from excavations of Northwest Coast prehistoric houses in which approximately half of the interior of the long houses appear to have been occupied by high status domestic groups while the other half of the interior was occupied by lower status domestic groups.

Thus, the debitage, chipped stone tools, fire cracked rock, and ground stone tools are essentially the same on the two halves of the house floor. Moreover, this is also true of the plant remains and the soil chemical concentrations that are clearly anthropogenic. All of these lines of evidence, together with similar patterning in large corporate residences on the Northwest Coast, strongly support the conclusion that special activities are not responsible for the strikingly different east versus west feature distributions across the floor. Therefore we can conclude that about one half of the constituent households of the large corporate houses were high status, 'elite' domestic groups. Although there were only a few prestige objects found on the floor, these were almost exclusively found in the western half of the house (including a copper bead, nephrite knife fragment and sculpted marble piece).

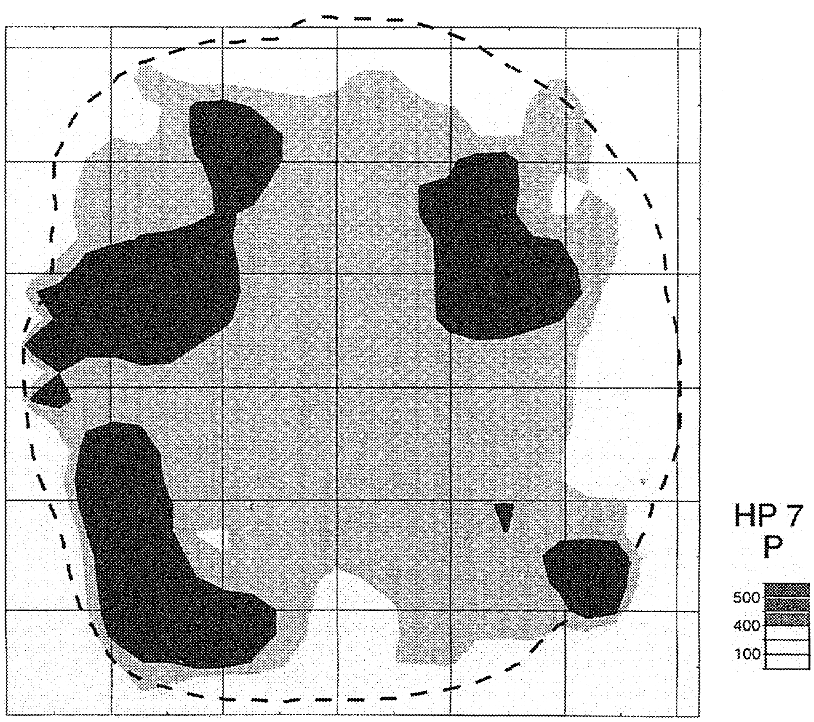
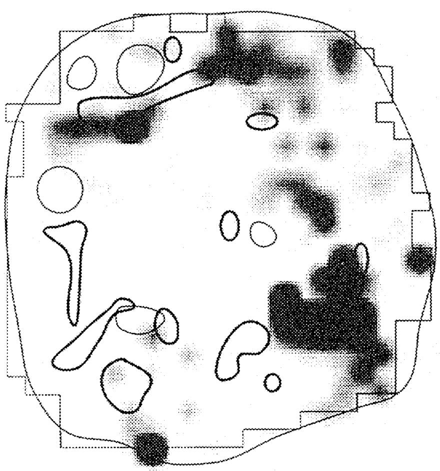
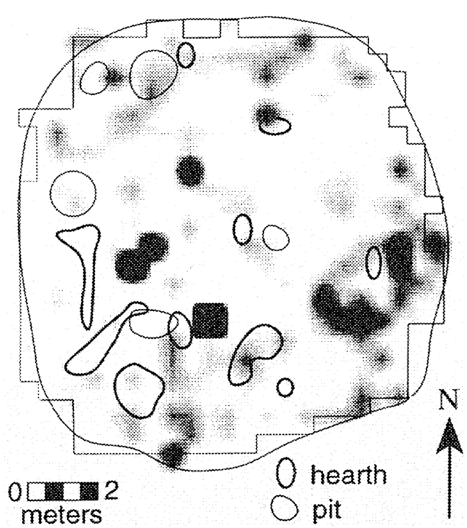


Figure 6 The high concentrations of phosphorous in the floor sediments around hearths also confirms the accurate identification of floor sediments and supports the argument that the same suite of activities was taking place on both the west and east parts of the floor (from Middleton, n.d.).

Such a high proportion of 'elite' domestic groups may seem surprising, however; this is consistent with ethnographic observations from the Lillooet region (Teit 1909: 576) as well as ethnographic observations of other transegalitarian societies at about the same level of complexity, such as those on the Northwest Coast (Ames, personal communication; Chatters 1989), in Highland New Guinea (Strathern 1971) and Highland Southeast Asia (Leach 1954: 149, 162–3, 214). In the Lillooet region and elsewhere on the Plateau, the most important fishing sites were described as being owned by 'brothers' or up to 6–10 of a single household (Teit 1906; Curtis 1911: 95; Spier and Sapir 1930). The four large hearths on the west side of HP 7 might well have been closely related members of a single



Fish Bone on the Floor of HP 7
Frequencies Range from 0 to 59



Non–Fish Bone on the Floor of HP 7
Frequencies Range from 0 to 159

Figure 7 The distributions of fish bones (Top) and mammal bones (Bottom) are more unequal across the floor and present more interpretive problems for analysts. Such differences may be due to socioeconomic differences, taphonomic differences in terms of the way fish bones were processed possibly accompanied with differences in species of salmon consumed, occupational specializations, sharing, recycling, or other factors (from Lepofsky et al. 1996).

descent line that inherited important economic rights over productive resources such as prime fishing localities or hunting areas. Such an economic and social configuration holds many implications for models of emergent complexity. It implies that initial aggrandizers could only further their own self-interest by sharing power and wealth widely. It also implies that aggrandizers could only convince others to produce surplus and surrender control of some of that surplus by convincing others that it was in their best interests to do so. Aggrandizers concocted many strategies to pressure people into producing and surrendering surpluses (see Hayden 1995), but these are not the focus of the present article.

Several other patterns are of interest on the floor of HP 7. First, there are far fewer concentrations of fish bones and mammal bones than there are hearths (Fig. 7). The formation processes of bone deposits is extremely complex since the most prized form of both meat and fish was as boneless fillets and the least prized portions were the fins and back bones. Nevertheless, it would appear that several domestic groups may have joined together around a single hearth to process and consume animal bones, and it is also possible that the vast majority of the bony parts of salmon were given to the poorer members of the house.

The second pattern of interest is a breakdown in the complementary distribution of stone tools along the wall versus the center-facing edge of the hearths. The breakdown in this patterning happens in the southernmost domestic area and is also characterized by unusually low densities of all artifactual material, even though there is a very pronounced series of large hearths in this area together with large storage pits (Fig. 8). The presence of the hearths and storage pits makes it seem unlikely that the low density of artifacts is due to the use of the area as a traffic corridor. On the other hand, ethnographically, the most important administrators, or 'chiefs', were known for their aversion to menial labor (Romanoff 1992a: 490, 497 – a pattern documented even more copiously for the Northwest Coast). Jim Spafford and I therefore tentatively propose that this may well have been the domestic area of the house 'chief' of HP 7 (Hayden and Spafford 1993).

Economic underpinnings of residential corporate groups

Thus far, it has been possible to identify the basic social organization within some of the large housepits on the Plateau and to infer some of the differing economic potentials of the elite versus the non-elite residents of these housepits. However, we have still not addressed the question of why and how these residential corporate groups came into existence and why some domestic groups had poor status while others were richer and more powerful, or why the poor decided to reside with the rich and vice versa. These issues are complex, but a summary of our understanding of them can be briefly presented.

On the basis of the analysis of salmon remains conducted by Kevin Berry, it appears that the residents of smaller and poorer housepits consumed exclusively pink salmon (recognized by the 2-year growth rings in their vertebral centrums). Pink salmon are the easiest species to catch, but are also the smallest and have the lowest fat content making them the least desirable species of salmon available in the Lillooet region. Residents of larger houses also consumed large amounts of pink salmon, but they were also the exclusive consumers of sockeye and chinook salmon (with 3–5 year growth rings). Sockeye and especially chinook salmon are larger, much stronger swimmers that keep farther away

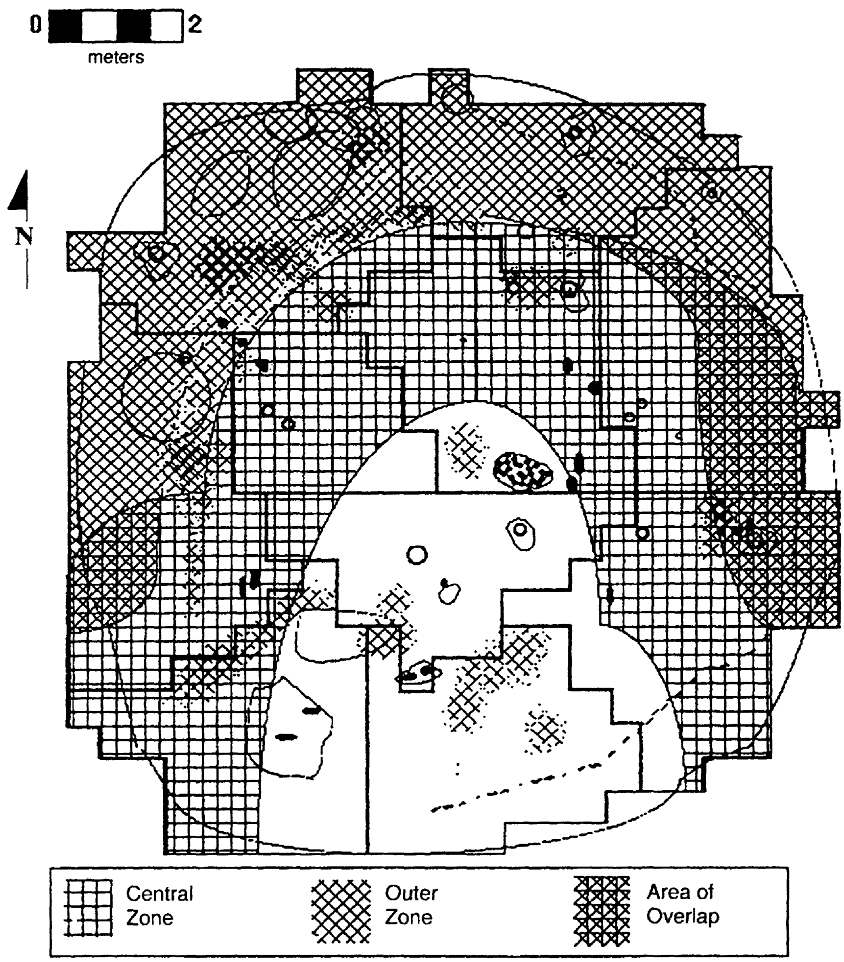


Figure 8 On the basis of the distribution of stone tool types, most of the house floor can be divided into a peripheral zone of activity between the hearths and the wall, and a more central activity zone between the hearths and the center of the floor. This pattern, however, breaks down in the southernmost part of the floor which is notable for the low density of debitage and stone tools, although it has several major hearths and storage pits. One explanation for this paucity of remains may be that the highest ranking administrator of the corporate group (the household 'chief') engaged in few menial tasks, similar to important chiefs on the Northwest Coast. This domestic area may have been his residence (from Spafford 1991).

from the shorelines so that it is only possible to catch them in quantity from special rocks that jut far out into the river or from specially constructed fishing platforms. Ethnographically, most of these fishing sites were owned by families (Romanoff 1992b; Kennedy and Bouchard 1992; Spier and Sapir 1930: 175; Curtis 1911: 95). Archaeologically, the fact that sockeye and chinook salmon bones only occur in the larger houses at Keatley Creek implies that the residents of these houses had access to the fishing locations for obtaining these prized fish while the residents of smaller poorer households did not. This means that some sort of ownership over, or recognized privileged access to, these fishing locations existed for the members of the large residential corporate groups.

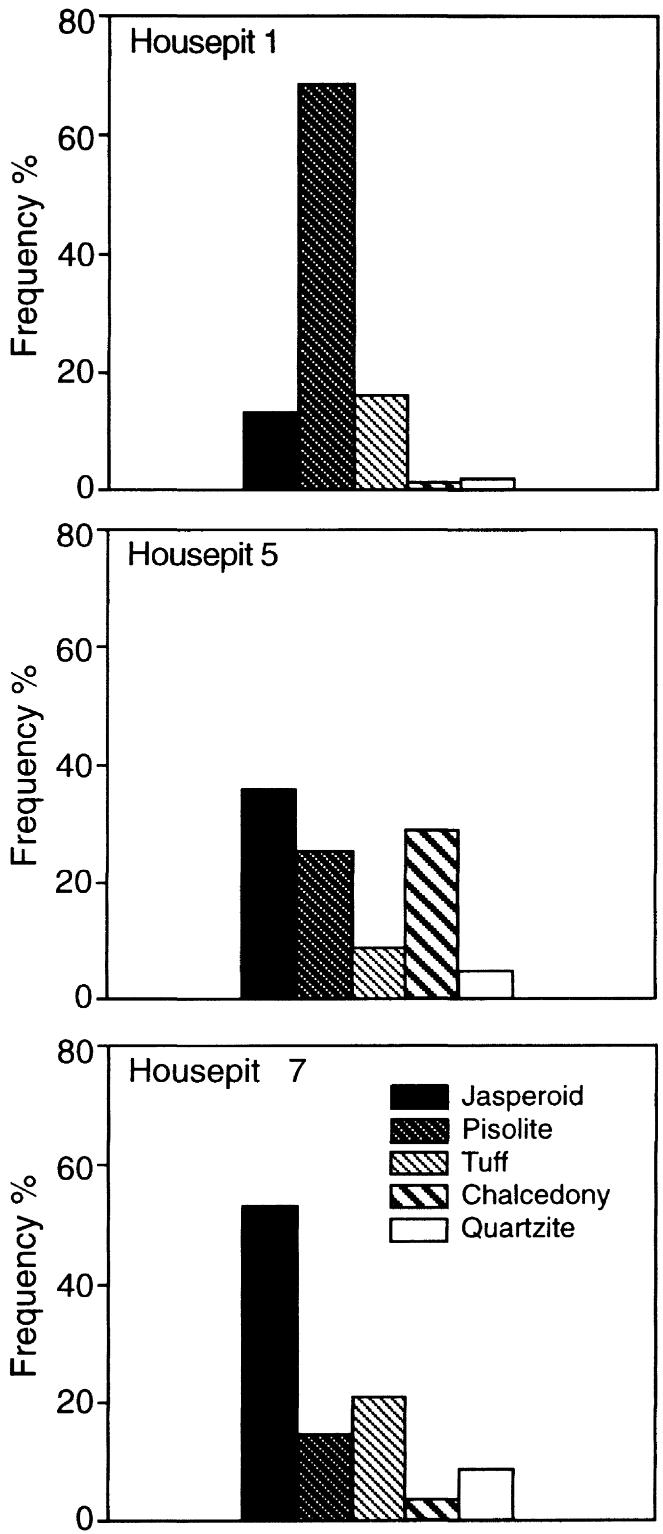
Since salmon provided about 70 per cent of the total protein for the prehistoric residents of the region (Chisholm et al. 1982, 1983) and since dried surplus salmon was traded far and wide from the region ethnographically, it seems reasonable to conclude that control of the most productive and the most lucrative fishing sites was the main reason for the formation of the large residential corporate groups at Keatley Creek. The elite members of the houses held the proprietary rights over the means of production and they probably engaged or enslaved other individuals to provide labor during the most labor-intensive peaks of the salmon runs. Many poorer families, or families without rights to lucrative fishing sites, would undoubtedly have found the prospect of working for a wealthy, powerful corporate household very attractive.

Slaves or commoners probably also performed much of the drudge work associated with the corporate group. Ethnographically, slavery was widespread all along the Northwest Coast as well as in the major productive centers on the Northwest Plateau (Mitchell and Donald 1985; Teit 1909; Spier and Sapir 1930). It seems evident from the copious prestige assemblages associated with some burials in the region (Stryd 1973; Pokotylo et al. 1987) that the elite members of the large corporate groups benefited greatly in material terms from their control over these resources and from the work of others. Trade shells and whale bone from the coast attest amply to the production of surpluses that were traded. Other items were undoubtedly involved in this exchange including nephrite celts (Darwent 1996), copper beads, furs, buckskin, slaves, stone and bone carvings, pipes, and obsidian (Hayden and Schulting 1997).

Finally, from a detailed and innovative petrographic and petrochemical analysis of the stone debitage associated with the housepits at Keatley Creek, Ed Bakewell was able to demonstrate that each large housepit was associated with a distinctive source or combination of sources of chert-like materials (Fig. 9; Bakewell 1995; Hayden et al. 1996). This not only confirmed the fact that each large contemporaneous housepit formed a socially and economically separate entity, but it also indicated that each large housepit was probably exploiting a different exclusive mountain area for hunting and root-gathering, since the sources for the different chert-like materials were located in different areas of the mountains above Keatley Creek and the ethnographic record shows that these mountain areas were used as summer hunting and root gathering areas. These findings reinforce the interpretation that the ultimate *raison d'être* for the residential corporate groups at Keatley Creek was the control of economic resources and the enhancement of elite member wealth and power.

However, the analysis of the debitage from the rim middens of these same houses led to two other unexpected and rather astonishing conclusions. In all the large houses sampled, these rim middens began to be deposited during the Shuswap Horizon (3500–2400 BP) with

Figure 9 These histograms clearly show that three of the largest residential corporate groups at Keatley Creek used dramatically different suites of chert-like materials. Since these materials are available within 20 km of the site, the almost exclusive use of some of these sources by residents of a single housepit implies privileged access if not ownership of those resource and undoubtedly the hunting and root collecting areas nearby. Large structures were occupied during the same time periods at the site. The fact that these patterns of use stay relatively constant throughout the occupation of each large structure (over 1,000 years) attests to an astonishing stability and continuity of corporate group rights and identity over time (from Hayden et al. 1996).



Housepit 1
Housepit 5
Housepit 7
Frequency %
0
20
40
60
80
Jasperoid
Pisolite
Tuff
Chalcedony
Quartzite

deposits ending sometime early in the Kamloops Horizon (1200–200 BP). The occupations of these large housepits thus overlapped and were contemporaneous to a very large degree. When we examined the suite of different lithic types in the rim middens of the largest housepits, we were surprised to find that the same distinctive types of materials were being used in the earliest levels of the stratified rim middens as in the latest levels, including the last floors. Indeed, there was very little change throughout the long sequence of refuse deposition for each house. This meant most importantly that the same distinctive corporate group had existed as an identifiable economic and social entity with inherited rights over discrete fishing and hunting areas for well over 1,000 years. In the realm of hunters and gatherers, this degree of stability was undreamed of by either ethnographers or archaeologists. It is nothing short of remarkable, and constitutes, as far as I know, the longest-lived documented corporate group anywhere in the world (Hayden et al. 1996). I doubt that this situation is unique, especially in situations where residential corporate groups were formed on the basis of their control over lucrative but highly localized resources like fishing rocks. I suspect that many more such instances of long-lived corporate groups will be discovered when archaeologists begin looking for this kind of patterning in their data; and I also suspect that even longer-lived corporate groups will eventually be documented.

The study of lithic materials also meant that the large house sites that we had excavated were held in the continual possession of the same residential corporate group for extremely long periods. It seems highly probable that, except for short re-roofing episodes, these houses were continuously occupied by the same evolving group. This, too, was an unexpected result since at the outset of the project it was not clear at all whether the large structures had even been continuously occupied.

Summary

Detailed excavation and analysis of housepit features and contents have enabled the team of researchers working on the Keatley Creek materials to reconstruct important details of the prehistoric economic and social organization at the site. We have been able to demonstrate that the formation of large residential corporate groups was based on the control of the most important surplus producing food resources (prime salmon fishing sites and hunting areas). Rights to these resources were probably inherited by descendants of the original developers or expropriators of these sites. How the rights were passed on, and how recruitment was organized, is not really critical for the archaeological investigation of residential corporate groups – and maybe is not even a retrievable type of information. Such details are not essential to archaeological interpretation. In fact, whether descent was unilineal, bilineal, or a bit of both depending upon specific rights or materials being passed on, is probably irrelevant in the study of archaeological social organization. What is important is that *some* system clearly existed for transferring these rights and materials and that this system persisted over many generations. I suggest that archaeologists should purge themselves of concepts that sociologists and others have developed for very different data sets, interests, goals, and questions.

On the other hand, while social anthropologists have seldom been concerned with the proportion of people that hold power in communities, or how that power was maintained,

or following actual behavior rather than emic concepts, it is clear in this archaeological study that about half of the domestic groups within the large residential corporate groups on the Northwest Plateau and Coast were privileged in terms of the resources controlled by the group while the remainder of the residents occupied a client or even slave status. This has substantial implications for our understanding of the initial emergence of socio-economic inequalities. Moreover, the persistence of the largest and most successful of these residential corporate groups as discrete, identifiable entities for over a thousand years is a remarkable testimony to the powerful effect that control over lucrative economic resources can exert over the social structure of transegalitarian communities, whether complex hunter/gatherers or agriculturalists.

In the final analysis, close study of the ecology, economy, and technology of prehistoric cultures can provide a sound basis for the interpretation of artifact and feature patterning related to social organization. However, it is important to frame concepts and questions in terms suited to the archaeological record. This does not exclude the more relativistic interpretation of symbols using other approaches, but conclusions based on cultural ecology, practical constraints, and reality testing certainly seem to be more sound than ones based on subjective assessments and speculative readings of symbols and patterns.

Acknowledgements

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Trade and technology of the Indus Valley: new insights from Harappa, Pakistan

Jonathan M. Kenoyer

Abstract

This paper presents selected results of current research on specialized crafts at the early urban center of Harappa, Pakistan. Many crafts such as shell working, ceramics, and agate and glazed steatite bead making are represented from the earliest levels of the site (*c.* 3300 BC) and continue up until the final phase of prehistoric occupation (*c.* 1700 BC). Materials analysis and sourcing, microscopic studies of manufacturing waste and finished objects, experimental replication, and ethnoarchaeological studies have been used to investigate the trade of raw materials and finished objects, as well as the development of technological innovations. Some of these crafts are still practiced in the subcontinent today, and by using more precise methods of analysis and documentation it will be possible to follow the continuities and change of some crafts for over 5,000 years.

Keywords

Harappa; specialized crafts; shell working; ceramics; beads.

Introduction

The ancient site of Harappa, Pakistan, one of the largest cities of the Indus Valley Civilization (*c.* 2600-1900 BC – dates based on calibrated radiocarbon values), has been the focus of periodic archaeological excavation and scientific research for over 125 years (Dales and Kenoyer 1993) (Fig. 1). Together with the site of Mohenjo-daro, located some 590 kilometers to the south, these two cities have been the major source of information for understanding the nature of ancient Indus cities and the civilization as a whole (Possehl 1990; Kenoyer 1991; Jansen 1994). Regional surveys and excavations at smaller settlements throughout the northwestern portion of the subcontinent have provided additional details of urban–rural interaction, and revealed the presence of trade networks that connected the major urban centers with regional centers and resource areas (Misra 1992; Mughal 1992).

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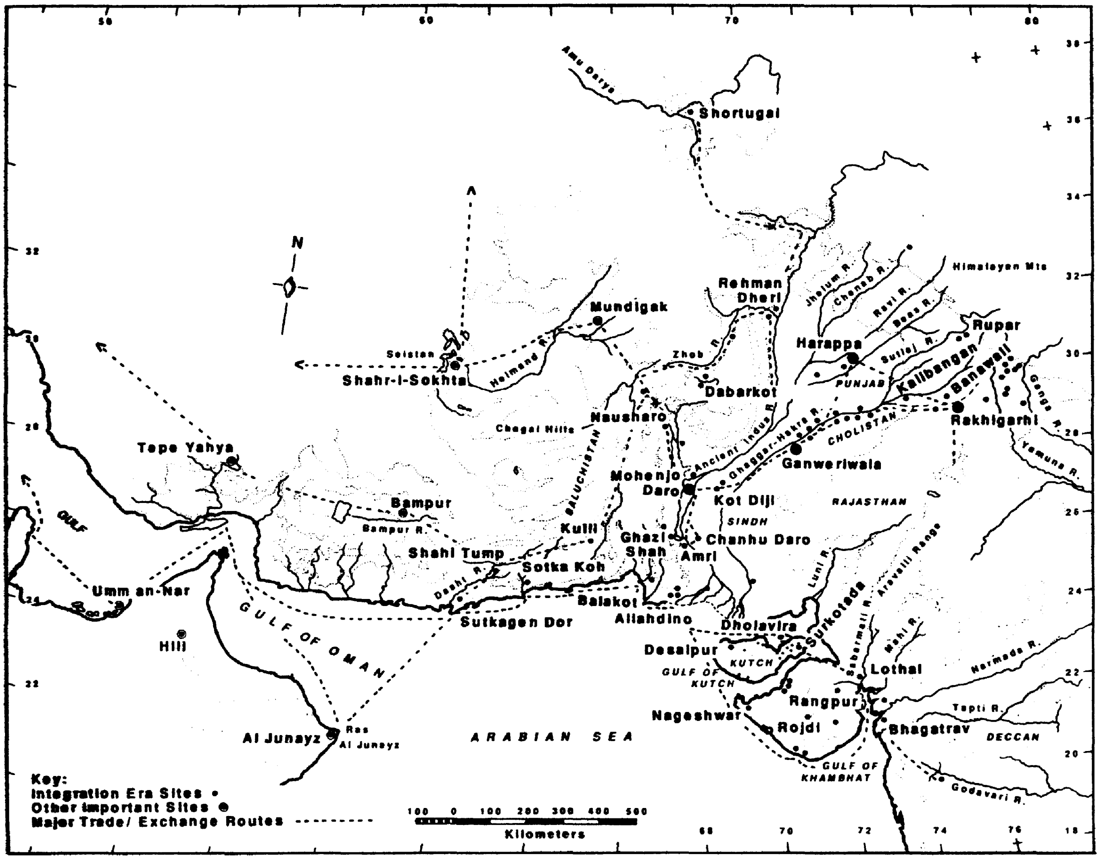

Figure 1 Map of the Indus Valley with major sites.

The geographic area encompassed by the Indus civilization was twice the size of that controlled by Sumerian city states or Dynastic Egypt, and the mechanisms of control and integration may have been significantly different from what is known in those regions. Some Indus settlements, such as Harappa, had massive walls and gateways, but they may have been more important as control mechanisms to facilitate taxation and limit commercial access or exit from the cities, than for military defense (Kenoyer 1993, 1997). Monumental buildings have been found at Harappa and Mohenjo-daro, but no centralized ritual or political structures, such as temples, palaces or royal burials, have been identified. This pattern suggests that no single individual or dynasty dominated the cities for very long, and that they may have been controlled by several competing groups of elites, i.e. land owners, merchants or ritual specialists (Kenoyer 1994a). Collectively, these communities appear to have established and maintained order and hierarchy among the many different social classes and economic groups that would have been present in the large cities.

At present, given the undeciphered script and the lack of graphic representations of control, the most rewarding method for understanding the socio-political and economic organization of Indus society is through the study of craft organization, particularly

technological stages of production and trade. Current research expands on studies begun by the earlier excavators of Mohenjo-daro and Harappa, who devoted a considerable effort to documenting technological details of a wide variety of objects. They undertook scientific analyses of raw materials and manufactured objects using all of the most powerful techniques available at the time (Marshall 1931; Mackay 1938, 1943; Vats 1940). In fact, many of the analyses were so thorough that their results continue to be reconfirmed in the course of current research. These early excavators also made ethnographic observations of traditional crafts and trade mechanisms, and used these analogies to shape their interpretive statements about the relevance of specific materials to trade and economic networks, as well as to political and religious structures.

Today, however, with new and ever changing research paradigms, the scale of material culture studies has changed and the complexity of interlinked data sets has been dramatically increased. With rigorous methods of recording and analysis, combined with computer-aided data processing, totally new spheres of investigation and interpretation have been opened up. Some of the important themes that have been the focus of recent work at Harappa and other sites include the segregation and control of production, the organization of production and political control, and the identification of direct vs indirect control of specialized crafts by elites (Kenoyer 1989; Vidale 1989a, 1997; Bhan et al. 1994 for summary and biblio.; Miller 1994, 1997a, 1997b; Wright 1991).

The identification of direct methods of control is relatively straightforward and relies primarily on archaeological excavation and recovery; defining indirect control is somewhat more complicated. Ethnoarchaeological studies of crafts, such as agate bead production and pottery manufacture, indicate that the mechanisms for indirect control are to some degree determined by the type of raw material and its availability, the technological stages of production, the complexity of the manufacturing process itself and, finally, the cultural value or symbolic nature of the final product (Kenoyer et al. 1991; Vidale et al. 1992). Any or all of these factors can change as new resource areas open up, as more advanced technologies are developed and as cultural values fluctuate. In addition to ethnoarchaeological studies, problem-oriented experimental replication is essential for a full understanding of the processes of manufacture used in the past. Both of these perspectives help in selecting more meaningful sets of archaeological data for analysis, as well as in developing the interpretive models employed in their explication. When several data sets have been correlated it has been possible to distinguish threads of continuity and patterns of change in the economic interaction and technology of the ancient Indus cities (Kenoyer 1995a and b).

In our research at Harappa, we have tried to implement this type of complex, long-term and often tedious investigation in conjunction with more specialized scientific analysis of the artifacts themselves. It is important to emphasize that high resolution analysis of artifacts can only produce meaningful results and reliable interpretations if the archaeological context is clearly defined. The earlier excavators of Harappa used the most refined techniques available at the time, but their recovery and recording procedures were not appropriate for addressing the questions that are being raised today.

In this paper I will present selected results of current research on the production and use of agate and steatite beads, ceramics, and marine shell. These examples illustrate how different analytical approaches have been combined in the investigation of Indus craft

technologies and trade. Owing to limitations of space many supporting data, such as excavation plans, stratigraphic section drawings, artifact counts and percentages in each excavation unit are omitted. These details, along with chemical characterization, mineralogy, and petrographic analysis, can be obtained from recent field reports and the references provided in the text.

Background and chronology

In 1986, a long-term program of investigations into the origins and character of Indus urban centers was initiated at Harappa by the late Prof. George F. Dales and Dr J. M. Kenoyer (Dales and Kenoyer 1991, 1993). In 1992, the original University of California-Berkeley project was transformed into the Harappa Archaeological Research Project (HARP) with 1997 marking the fifth field season of the reoriented project directed by Drs R. H. Meadow (Harvard University), J. Mark Kenoyer (University of Wisconsin-Madison), and Rita P. Wright (New York University). Excavations at Harappa are conducted in collaboration with the Department of Archaeology and Museums, Government of Pakistan.

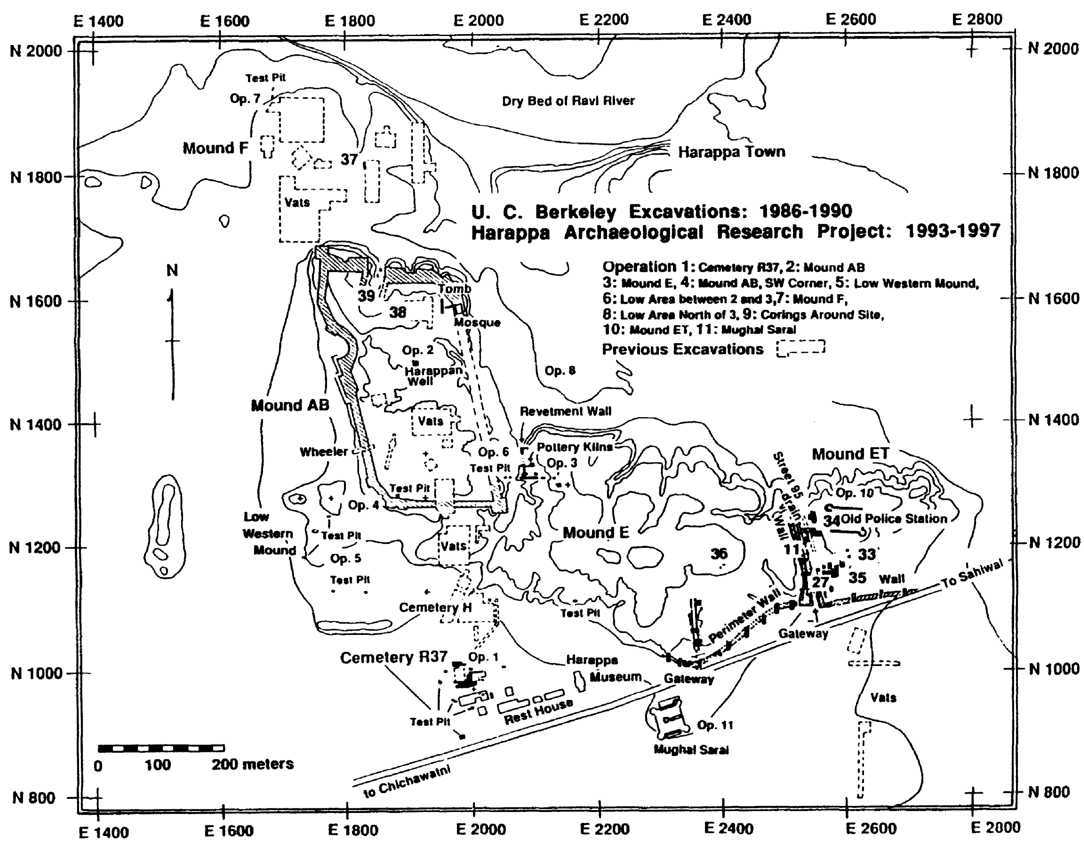

Figure 2 Harappa 1986–97 excavation areas.

Table 1 Provisional prehistoric chronology of Harappa

Period 1A and 1B Early Harappan	
(Ravi-Hakra Phase)	*c.* 3300–2800 cal. BC
Period 2 – Early Harappan/Harappan Transitional	
(Kot Diji Phase)	*c.* 2800–2600 cal. BC
Period 3 – Harappan Phase	
Period 3A	*c.* 2600–2450 cal. BC
Period 3B	*c.* 2450–2200 cal. BC
Period 3C	*c.* 2200–?1900 cal. BC
Period 4 – Harappan/Late Harappan Transitional	no dates
Period 5 – Late Harappan	?–1700 cal. BC

Five major periods of pre- and protohistoric occupation between *c.* 3300 and 1700 BC have been defined using architectural phases, diagnostic artifacts and seventy radiocarbon dates from primary context hearths or floors (Table 1; Meadow 1991; Meadow and Kenoyer 1993, 1994, 1997). Many of the samples have been split and sent to two or more laboratories, including the University of Wisconsin-Madison, University of Arizona, University of Washington, Seattle, and Beta Analytical.

On the basis of the most recent work at the Harappa in 1996 and 1997 (Fig. 2), it appears that the first settlers at Harappa established a small agricultural village near the ancient Ravi River around 3300 BC (Periods 1A and 1B). This location was ideal for agriculture as well as for access to rich hunting and fishing grounds. The earliest village occupation is characterized by small mud-brick buildings and skilled artisans practiced a wide range of crafts: hand-built pottery, copper/bronze working, and making ornaments from semi-precious stone and marine shell (Kenoyer 1991; Meadow et al. 1996). As the settlement became more established it also gained importance as a crossroads for trade between the highlands to the west and north, and the vast alluvial plains to the east and south. By 2800 BC (Period 2) the village had grown into a town that covered more than 25 hectares. Within two hundred years this town became one of the largest cities of the Indus Valley Civilization. During the Harappa occupation, 2600–1900 BC (Periods 3A, 3B, and 3C) the city was spread out over 150 hectares, an area that included several low mounds and three high mounds, one of which stands more than 17 meters (60 feet) above the original plain level.

Craft technologies: general and high definition analysis

Agate and steatite bead making

Bead-making studies that have been implemented at Harappa are closely integrated with a larger study involving bead making at various sites of the Indus valley and adjacent regions, as well as distant Mesopotamia (see Bhan et al. 1994 for biblio.). These studies have attempted to access different levels of information about the cultures in which beads were produced, traded and used. By using X-Ray Defraction, Scanning Electron

Microscopy, Electron Microprobe, and the help of computer-based data management systems, current research on the bead industry at Harappa is going far beyond anything that was envisioned by earlier bead scholars such as E. J. H. Mackay and H. Beck.

Petrographic characterization of the different types of raw materials available to Indus artisans indicates the presence of numerous sub-varieties of steatite (Vidale and Bianchetti 1997), lapis lazuli (Casanova 1994) and agate (Trivedi 1964). The source areas for the raw materials are located in distinct geological formations surrounding the Indus valley, and the acquisition of these rocks would have involved overlapping trade networks, all of which ultimately ended up at Harappa or other major Indus settlements (Lahiri 1990).

At Harappa, in Period 1 (3300–2800 BC) there is evidence for two major types of stone bead manufacture: hard stone beads made of carnelian, agate, jasper or lapis lazuli, and soft talcose stone beads (steatite or soapstone). The talcose beads were later hardened, whitened or glazed by firing in high temperature kilns (Vidale 1989b; Vidale and Bianchetti 1997). The differences between these two technologies, from raw material acquisition to final distribution of finished beads, are critical to understanding the relative 'value' of beads and for defining the different ways in which production was organized and eventually controlled by elite groups (Vidale 1997). For example, agate beads become marketable or usable only after drilling and polishing, while steatite beads must be hardened and glazed by firing in high temperature kilns before they can be used. Consequently, control can occur at different points in the production sequence and could be reflected archaeologically by the patterning of manufacturing indicators (Kenoyer et al. 1994).

At present we have excavated only a small area of Period 1 deposits (4 × 3 meters) (Fig. 2: Trench 39S), but in a series of floor levels we recovered two flakes from agate bead making and 153 unfinished steatite beads, one sawn steatite fragment, and 1,450 finished steatite beads, some of which were *in situ* necklace fragments. The association of the agate materials may be the result of post-depositional processes and does not necessarily mean that the same artisans or households were producing both types of beads.

The finished steatite beads had been hardened and whitened by glazing and firing at high temperatures and some of the long cylindrical beads were decorated with a blue-green glaze. This glaze was probably made with powdered frit and copper oxide combined with a flux from plant ash (*sajji*), a process that is well documented for glazed faience (Kenoyer 1994a). The temperatures needed to harden the steatite range from 900°–1,000°C, and by using a flux the glaze can be produced at around 940°C (Kenoyer 1994a). The stages of manufacture and firing of the beads from Period 1 at Harappa are generally comparable with what has been reported from the site of Nausharo (Vidale 1990; Barthélémy de Saizieu and Bouquillon 1994).

However, additional SEM studies of the saw marks on the manufacturing waste provide some new information on the earliest metal saws used at the site. The early saws left non-parallel sawing striae with rounded edges, that may be the result of unskilled sawing (or a badly made saw) and the softness of pure copper (Plate 1a). No samples of early saws have been recovered but the saw marks point to a relatively unrefined form of saw. In contrast, sawn steatite manufacturing waste recovered in 1997 from early street levels of the Harappan period on Mound AB (Period 3A, *c.* 2600 BC) reveal the use of a more refined and standardized type of saw. The parallel striae indicate a very regular

a. b.

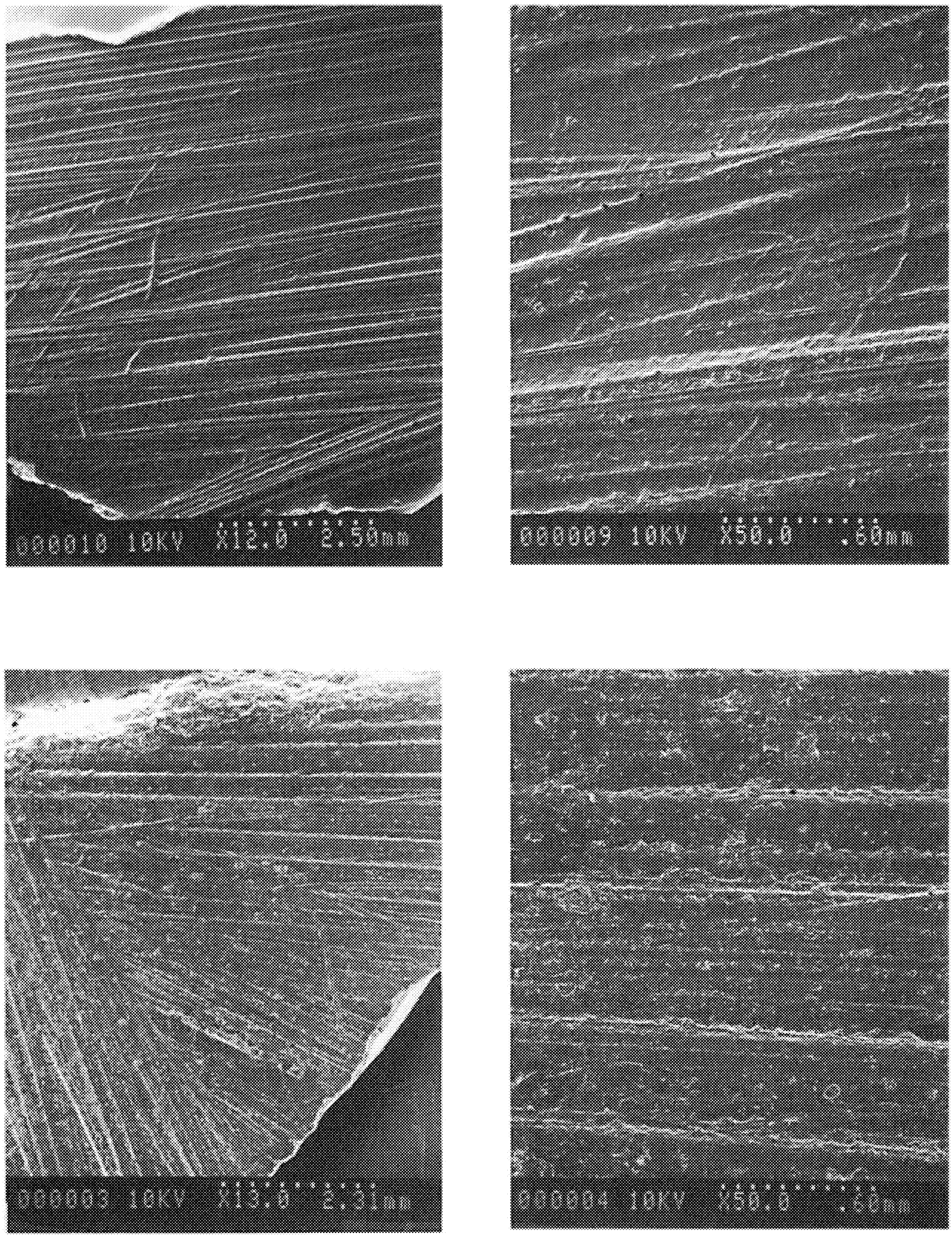

Plate 1 SEM of sawn steatite manufacturing waste: a. sample H96/7531-8, Period 1A (*c*. 3300–2900 BC); b. sample H97/7755-2, Period 3A (*C* 2600 BC).

denticulation and efficient bi-directional cutting motions (Plate 1b). The edges of the saw strokes are quite angular or crisp, suggesting that the saw blade was much harder.

A discarded copper alloy saw was recovered along with the steatite manufacturing waste (Period 3A), and although it is badly corroded, large and regular denticulations are preserved along one edge. The thickness of this saw edge is 0.35 to 0.43 mm and corresponds proportionally to the width of actual saw cuts on steatite waste, which range from 0.7 to 1.0 mm in width. A sample of the Harappan period saw blade has been collected for compositional and structural analysis (at MASCA, University of Pennsylvania) in order to determine if the saw was made of hardened copper or bronze. Replicative analyses will include the manufacture and use of thin copper and bronze saws with different types of denticulation to determine the types of striae that would result from various methods of sawing.

The area exposed for Period 2 is much greater than for Period 1 and includes trenches in five different areas of the site, but no significant concentrations of manufacturing debris have been discovered. Nevertheless, studies of the finished beads reveal important stylistic modifications, the use of more refined saws for cutting the steatite and the introduction of faience technology.

Considerable evidence for both agate and steatite bead making has been recovered from various parts of the site during Period 3 (2600–1900 BC). Most of our investigations of these technologies have focused on the identification of primary manufacturing areas and specific techniques of manufacture, with a special emphasis on indicators of control by elites. Both of these technologies developed side by side at Harappa, but the organization of production stages and the varying uses of pyrotechnology, drilling techniques and finishing are quite distinct. Agate beads were generally produced by several stages of heating, flaking, grinding, drilling and polishing (Kenoyer 1986; Kenoyer et al. 1991). Steatite beads on the other hand were made by sawing, drilling, fine grinding, glazing, and heating in kilns to harden the raw material and color them white or blue-green (Vidale 1989, 1990b; Vidale and Bianchetti 1997). Although agate and steatite bead making represent two very different craft traditions they often appear to be associated in the archaeological record and in the past archaeologists have often grouped them together. Current analysis of artifact percentages, especially microdebitage from primary manufacturing stages, indicates that the association of these two craft traditions may in fact be the result of secondary dumping from adjacent workshops rather than because these beads were being made by the same artisans.

On Mound ET steatite working has been identified in a restricted area inside the city wall and associated with numerous other crafts that were used to produce items for elite consumption and trade (Trenches 27, 28, 32) (Meadow and Kenoyer 1997). These crafts include agate and other stone bead making, shell working, bone and ivory carving and chert weight manufacture. Chert tool manufacture and use is quite common in this area and may have been associated with wood working or furniture inlay setting. There are also some indications of copper tool and ornament production, gold ornament making and faience production. Specialized ceramic vessels coated with what appears to be steatite powder may be associated with the firing of steatite beads or faience objects and are currently being studied by several scholars (Miller 1997a).

Many of the indicators for these crafts come from fine screening of the sediments or water separation to obtain microdebitage by the removal of fine silts. Microdebitage from

all stages of production is a strong indication of primary working areas, or the total maintenance and dumping from such areas. Microdebitage from steatite bead manufacture has been found on the floors of some structures near the gateway on Mound ET, indicating the proximity of primary bead manufacturing areas.

In contrast, excavations in adjacent areas on Mound E and ET have not revealed any evidence for steatite or agate bead working and this suggests that both agate and steatite bead making were restricted to a small area inside the gateway, associated with numerous other specialized crafts. The location of these crafts in a restricted area inside the gateway cannot be interpreted as direct control by urban elites, but it does indicate a degree of indirect control through the regulation of movement into and out of the craft area. This pattern is seen in craft bazaars in traditional cities of the subcontinent today. Proximity of specialized crafts is often the result of intentional zoning by rulers to facilitate interaction between related crafts, to benefit the public by providing a centralized area where all of the crafts are located, and especially to make it easier to collect taxes. At Harappa, the relatively high proportion of chert weights and weight manufacturing debris in the area just inside the gateway suggests that these measurement devices may have been used in evaluating goods for taxation, in addition to their general commercial application (Kenoyer 1997).

Bead perforation techniques

Perforation of stone beads by pecking or drilling has turned out to be a culturally informative detail of Harappan lapidary that was never fully appreciated by earlier scholars. With the invention of high quality silicon-based impression materials such as vinyl polysiloxane, it is now possible to make extremely precise molds of bead perforations that can then be examined by SEM. Experimental studies of perforation and drilling technology, using different types of tools or drill bits have made it possible to identify several different perforation techniques for stone beads during the Harappan Period. Most of the drilling would have been done using a bow drill, but it is possible that a more stable drilling apparatus was used for perforating the long carnelian beads. Perforations were usually achieved by working from both ends and joining the hole at the center of the bead.

Short biconical shaped beads of carnelian and agate reveal the use of a pecking technique that results in a rough hour-glass shaped perforation (Fig. 3a). A similar technique has been observed for short biconical beads from the site of Ur, dating to the mid-third millennium BC.

Copper drills appear to have been used to perforate soft stone such as steatite, but the actual drills are difficult to identify because of corrosion. Microscopic examination of drilling striae on experimental and archaeological samples of steatite indicates that the drill tips may have been simply beveled (Fig. 3b). So far there is no concrete evidence for the use of solid copper drills with abrasive, but a unique discovery in 1996 revealed the use of tubular drilling, presumably with a thin copper tube and a fine abrasive (Meadow et al. 1996) (Fig. 3c). Tubular copper drills used in Khambhat today have a slit along one side to allow the addition of the abrasive slurry. Tubular drilling was already known to have been used at Harappa for the perforation of large ringstones and for decorating large stone objects, but until now it has never been documented for small agate beads.

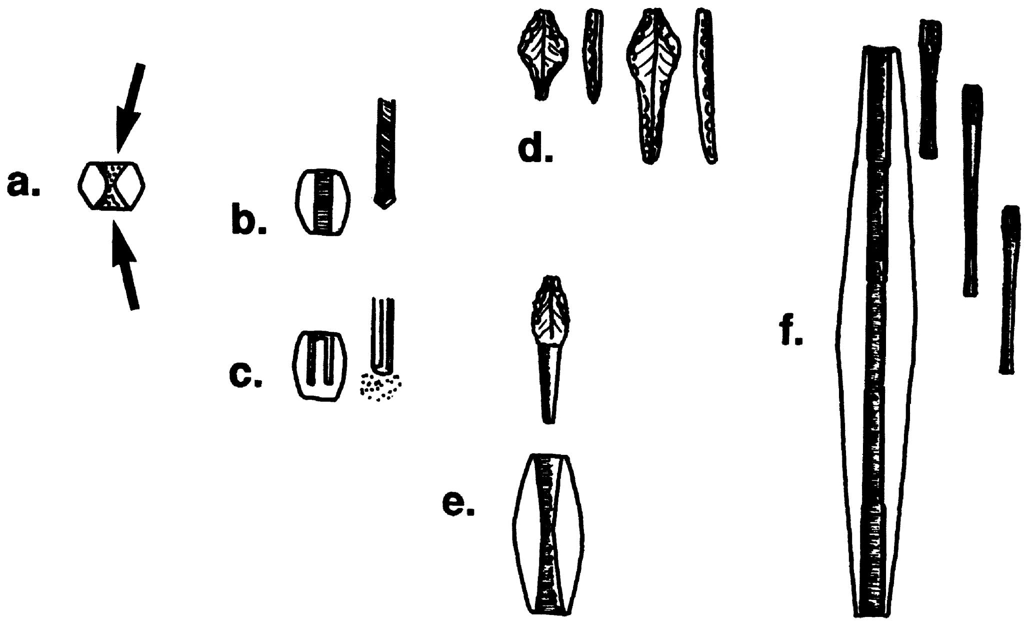

Figure 3 Bead perforations and drill types at Harappa: a. pecked drill hole; b. copper drill with bevelled tip; c. copper tubular drill with abrasive; d. short and long tapered chert drills; e. tapered cylindrical drill; f. constricted cylindrical drill in 3 sizes.

Preliminary study of bead drill holes from the craft area on Mound ET suggests that this tubular drilling technique may have begun during the late phase of the Harappan period (Period 3C), and it is well represented during the Late Harappan occupation (Period 5).

Long and short tapered drills, made by notching and steep retouch on chert micro-blades, are found in association with steatite and agate bead manufacturing debris (Fig. 3d). Some of these drills may have been used to perforate unfired steatite bead blanks, but most of them were probably used on shell, ivory or wood. Some of the tapered drills made of chert or jasper bladelets were modified into a more specialized form referred to as a 'tapered cylindrical drill' (Fig. 3e). These drills were used to decorate and perforate softer stone, such as lapis lazuli, turquoise, or limestone, and to perforate short beads of harder stone such as agate or carnelian (Kenoyer and Vidale 1992). This type of drill is found at sites throughout West Asia and the Indus Valley and has a long history of use at Harappa, beginning with the Period 1 occupation and continuing throughout Period 3.

Constricted cylindrical drills have only been reported from the Indus valley during the Harappan period and represent an important technological innovation (Fig. 3f). They have a long cylindrical shape that is wide at the tip and constricted in the mid-section. This shape was developed by the Indus artisans to facilitate the drilling of long slender beads of hard stone such as carnelian, agate, jasper and bloodstone. In contrast with the tapered drills, this type of drill is made from a specific raw material which is harder than most bead materials and can efficiently perforate carnelian and agate. Numerous studies using SEM, XRD and Electron Microprobe have been undertaken to characterize this rock, which was previously unreported in the geological literature of the subcontinent (Kenoyer and Vidale

1992). Macroscopically the rock has a mottled grayish-green to yellow-brown matrix with irregular dark brown to black patches or dendritic formations. Petrographically it is a fine-grained metamorphic rock composed primarily of quartz, sillimanite/mullite, hematite and titanium-oxide phases. Given the Harappan propensity for heating and transforming raw materials, it is not unlikely that the material was heated, thereby creating a new form of mineral composition as indicated by the presence of mullite (Keyser 1951). This drill material has been named 'Ernestite' in honor of Ernest J. H. Mackay, who excavated the site of Chanhudaro, where he discovered a carnelian bead workshop with hundreds of drills and drill manufacturing waste. At Harappa, ernestite drills and drill manufacturing waste are present alongside tapered cylindrical drills made of chert.

The simultaneous use of several different techniques for perforation in the crafts area on Mound ET at Harappa has important implications. These drilling techniques generally correspond to different types and qualities of raw materials that were being made into different types of beads for a diverse set of consumers. However, there is evidence that the same raw material was being perforated by two or more drilling techniques. For example, carnelian beads were perforated with pecking, tapered cylindrical drills, constricted cylindrical drills, and possibly tubular copper drills using an abrasive. At Harappa, these different drilling techniques may reflect distinct ethnic communities of bead makers with their own hereditary techniques or they could represent hierarchies of workshops catering to different clientele.

Ethnoarchaeological studies of agate bead making in Khambhat, India, indicate that this type of variation in technical knowledge and access to materials is closely associated with control of production and guarded technologies. The ability to maintain control of specialized bead production over several generations is often linked to stable hereditary trading relationships between highly specialized workshops and specific consumer groups (Kenoyer et al. 1994).

By using high definition analysis of drilling technology it also has been possible to identify more specific links between the technology and manufacturing processes of the Indus Valley and beads found outside of the Indus region. Detailed comparison between Indus drilling and the drill holes on long carnelian beads recovered from the excavations of the royal burials at Ur have confirmed that many of the beads from the Ur burials were made with the same technique as was found at the sites of Chanhudaro, Mohenjo-daro and Harappa (Plate 2). Stylistically and morphologically these beads fall within the range of variation found in workshops of the Indus Valley and it is most likely that these beads were made in the Indus valley. On the other hand, some of the shorter bleached carnelian beads have designs that are not of Harappan style and a few of the long carnelian beads are faceted, a style that is not used in the Indus region. Nevertheless, SEM studies of the bead drill holes indicate that these beads were drilled with ernestite drills (Bhan et al. 1994). Given the rarity of ernestite drills in the Indus Valley itself, it is not unlikely that this ancient drilling technology was a closely guarded trade secret, and that these beads were made by migrant Indus artisans residing in Mesopotamia around 2600 BC. These artisans probably had contacts with kin groups in the Indus Valley and from them obtained long carnelian nodules and ernestite drills. Some of these artisans may have been ancestors of the so-called Meluhhan minority that are documented in Akkadian texts, from 2350–2200 BC (Parpola et al. 1977).

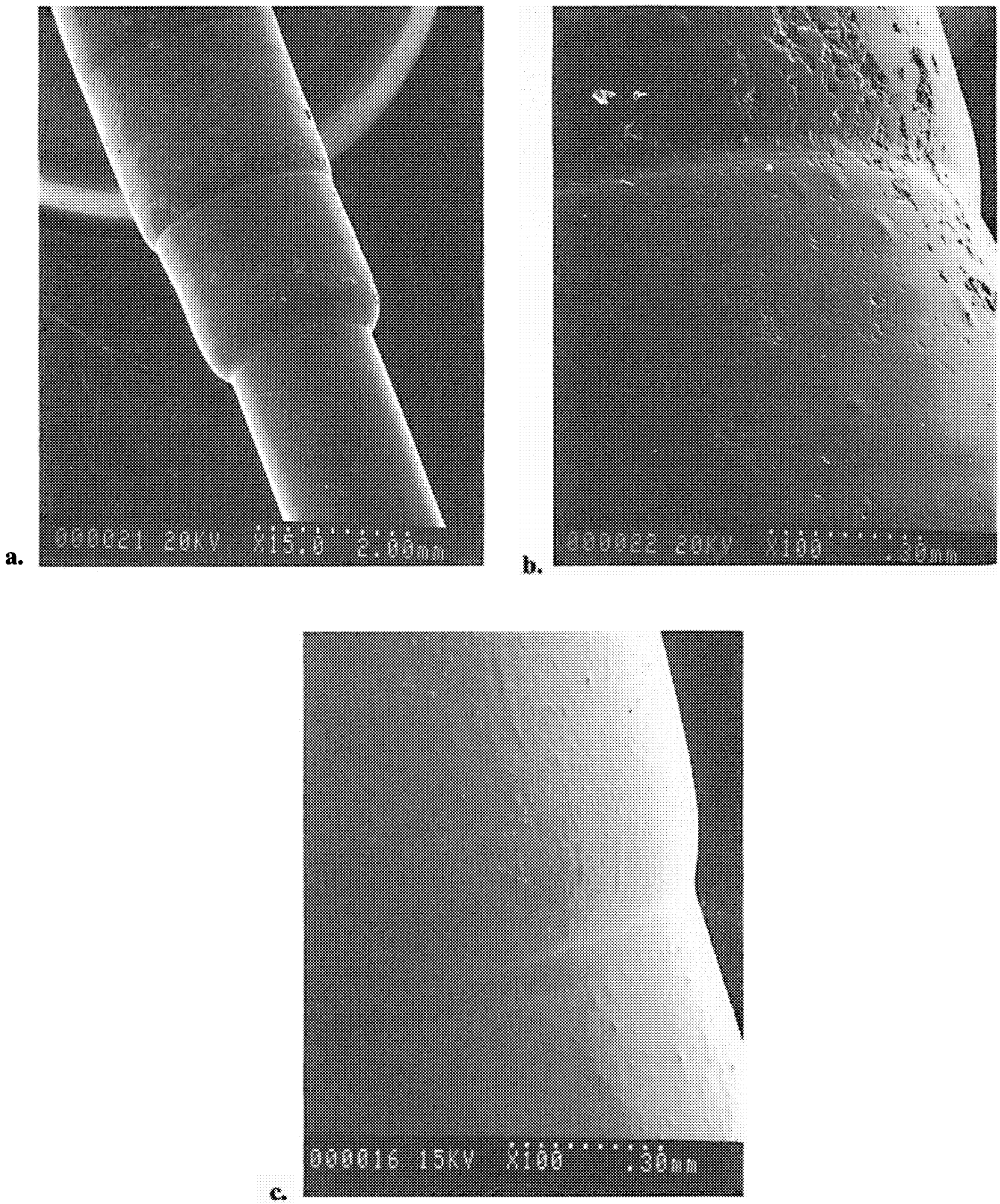

Plate 2 SEM of bead perforations: a. Chanhudaro, carnelian, long bicone, 15× (Museum of Fine Arts, Boston); b. Chanhudaro, carnelian, long bicone, 100× (Museum of Fine Arts, Boston); c. Ur, carnelian, long bicone, no. 16792.5; 100× (University of Pennsylvania Museum).

By looking at the context of these carnelian beads in Mesopotamia, it is possible to take this investigation one step further. Most of the long carnelian beads from Ur were found with serving ladies sacrificed outside the tomb of the queen Pu-abi (Woolley 1955). The

queen as well as her serving ladies were wearing golden flower headdresses that have been compared with terracotta figurines unique to the Indus Valley and found primarily at the site of Harappa (During-Caspers 1994). If some entrepreneurial Indus merchants and artisans were traveling to and residing in Mesopotamian cities, it is not impossible that Indus musicians and performers or serving ladies were also present there. The association of Indus beads with these serving ladies and the similarities of their headdresses with Indus-style hair ornaments is sufficient evidence to warrant a detailed comparison of their dental characteristics (most of the other skeletal remains are not preserved) with women from Indus cities such as Harappa. Such a study would be able to determine if there is any genetic relationship between these specific women and it could shed new light on the murky waters of international relations between the Indus Valley and Mesopotamia at this early time (Chakrabarti 1990).

Shell working

The study of shell working at Harappa is another example of how changing strategies of research have opened up new perspectives on the trade networks and technological developments of this important city. In the original excavation reports on Harappa, shell artifacts were divided into marine and riverine shell species, and most shell objects were thought to have been made from *Turbinella pyrum*, a large and heavy marine gastropod, commonly referred to as conch or sankh (Vats 1940). More detailed studies have revealed that three other species of marine gastropod, *Lambis truncata*, *Fasciolaria trapezium* and *Chicoreus ramosus* were also used in the manufacture of shell objects. In many cases the original shell species can be identified by microscopic examination of the shell growth layers on an object. In my earlier research of shell working industries at the site I was limited to the study of previously excavated materials, but these data were supplemented by ethnoarchaeological studies of traditional shell workers in Bengal and sourcing studies of specific shell species (Kenoyer 1984). These sourcing studies involved first-hand surveys of coastal areas to collect various species, and reconstruction of ancient coastlines and shell habitats. At least three major sources of marine shell appear to have been exploited by the Indus cities: the Makran coast west of Karachi, the Gulf of Kutch and Khambhat, and the coast of Oman. Initial studies by Monica Smith (University of Michigan – Ann Arbor) on shells obtained from the major source areas for *Turbinella pyrum*, indicate that it will be possible to trace most shells to each of the three major source areas (Monica Smith, personal communication). Harappa may have had access to all three sources and this will be studied using oxygen isotope and trace element analysis of manufacturing waste.

High-powered techniques have become essential for sourcing raw materials, but it is also possible to narrow the field of investigation by using microscopic analysis and studies of manufacturing techniques. For example we can look at the production of shell bangles at the Harappan coastal site of Balakot and compare this with what has been recovered from Harappa. At Balakot, similar looking bangles were produced using two different species of shell and involving two very different techniques (Dales and Kenoyer 1977). A single bangle was produced from each valve of the clam shell, *Tivela damaoides* (or *Meretrix meretrix*) by chipping and grinding. In contrast, numerous bangles in graduated

sizes were cut from the large gastropod *Turbinella pyrum* by sawing with a specialized type of bronze saw. The Tivela bangles made from clam shells have only been found at sites along the Makran coast, but a single heavily worn Tivela bangle fragment was discovered during my analysis of shell objects at the site of Lothal, which is located at the head of the Gulf of Khambhat, approximately 720 kilometers to the southeast of Balakot (Kenoyer 1984: 231). This Tivela bangle fragment represents some form of interaction between fisher folk or traders from the Makran coast and the Gulf of Khambhat.

In studying the shell artifacts from Harappa, I have been on the lookout for Tivela bangles or manufacturing waste, and finally discovered a single worn bangle fragment from the craft workshop area on Mound ET. This is an area with considerable quantities of shell manufacturing debris from the production of bangles, ladles, inlay and beads. The single Tivela fragment indicates that there was some contact with the Makran coast, and now it will be important to determine the proportion of shell raw materials that were brought to Harappa from this region as opposed to other areas. In order to answer this question, representative random samples of shell manufacturing debris from the different shell workshop areas of Harappa will be selected for isotopic studies and trace element analysis. This should provide some statistical evidence for the scale of trade with different coastal resource areas during the Harappan period, 2600–1900 BC.

On the basis of my earlier studies at Harappa and other sites in northern Pakistan, I have argued that trade contacts between the coast and the northern Indus regions began in the latter part of the Kot Dijian Period, which is equivalent to Period 2 at Harappa (2800–2600 BC) (Kenoyer 1984, 1991). This model must now be revised because, in 1996, excavations of the earliest occupation levels (Period 1A and B: 3300–2800 BC) recovered several fragments of *Turbinella pyrum* manufacturing waste and finished bangles of the same species. It is not unlikely that these raw materials and finished bangles came from intermediary sites and that the trade was relatively indirect. Nevertheless, oxygen isotope and trace element analysis can be used to determine the most probable coastal origin for these objects and the possible trade networks that were being used during this early period.

Moving from the aspects of trade and manufacture we come to the question of who wore and used shell bangles. The presence of shell bangles in Harappan burials indicates that adult women wore several bangles on the left arm and in one case a man was found with a single shell bangle (Kenoyer 1992). The absence of gold, bronze, and faience bangles in the burials suggests that certain wealth items were being passed on to younger women. Although shell bangles were quite valuable in terms of rarity of material and difficulty of manufacture, their inclusion in the burials suggests that they held specific ritual or symbolic meaning for the women who owned them. Ethnographic studies in South Asia indicate that white shell bangles are symbols of ritual purity and marriage status, and it appears that the symbolic importance of shell may have had its roots in the Indus culture (Kenoyer 1992).

Another interesting pattern is seen in the gradual reduction of shell bangle widths from the earliest to the latest burials. Ethnographic observations in South Asia indicate that women who are involved in heavy manual labor tend to wear sturdy bangles of shell, ivory, or precious metals, while urban elites who do not engage in manual labor tend to wear more delicate ornaments made of these same materials. I have argued that the thin shell bangles in the later burials at Harappa may indicate that these women were doing little or no manual labor and that they represent an elite community of Harappa (Kenoyer

1992). In summary, these analyses of Harappan shell bangle types and stylistic changes provide a new perspective on the use of bangles in the Indus cities and it appears that they were used predominantly by women to define their social status and ethnic identity.

Other crafts

In addition to these two categories of crafts, ongoing studies of other important crafts and trade patterns signal the beginning of a new era in the study of Indus Valley civilization. Current analysis and sourcing of the varieties of chert used in domestic and craft activities at Harappa indicate that there were major changes in trade networks between the different occupational periods. Petrographic and Neutron Activation analysis of stoneware bangles, which are known to have been produced at both Mohenjo-daro and Harappa, have confirmed the transport of these elite objects from one site to the other during the Harappan Period (Halim and Vidale 1984; Blackman and Vidale 1992).

The production and trade of black slipped storage jars (Méry and Blackman 1996) is another example of how such studies have contributed to our understanding of trade networks during the Harappan Period. Black slipped jars used for storage and trade of specific commodities have been found at most Harappan sites as well as in numerous sites in Oman. Petrographic and Neutron Activation analysis of jar fragments from Harappa, Mohenjo-daro and other Indus sites have been compared with those from Oman. The results indicate that clays used to make black slipped jars at Mohenjo-daro and Harappa are quite distinct and that all samples of black slipped jars from Oman can be traced to sources in the southern Indus Valley, such as Mohenjo-daro.

The possible contents of these jars are currently being studied by C. P. Heron using chemical extraction techniques. This research could provide a clue to decipherment of the Indus script, because almost every black slipped jar has pre-firing inscriptions or potter's marks, and those used for trade are almost always inscribed with post-firing graffiti. If the contents of these vessels can be defined and differentiated, it is possible that the writing may refer to specific commodities, a break-through that would certainly help in the eventual decipherment. On the other hand, the inscriptions may represent names of consumers or merchants. Studies are underway to see if any of the jar inscriptions correspond with known seal or tablet inscriptions from Harappa and other Indus sites. By combining all of these various methods of analysis we hope to be able to determine more precisely the role of these important vessels in economic interaction at Harappa and at the larger regional or international level.

The technology of stoneware production disappeared with the end of the Indus cities and, with the breakdown in trade networks, black slipped jars were no longer produced for shipping commodities between the Indus cities and distant resource areas. However, some crafts such as faience production, shell working and bead making continued to be important craft traditions the subcontinent and provide an important link between the technologies of the Indus cities and later urban cultures (Kenoyer 1995a).

Replicative studies and analysis of Harappan faience objects have revealed the development of a compact glassy faience (McCarthy and Vandiver 1990; Kenoyer 1994b) that may have important implications for the indigenous development of glass technology in South Asia. In 1996 a red-brown glass bead was found with a hoard of beads in a room dating

to approximately 1730 BC during the Late Harappan period (Meadow et al. 1996). Being the earliest glass bead from the Indus valley, this tiny object may in fact represent the beginning of local glass production. This same color of glass bead is relatively common from surface collections at nearby sites of the Early Historical period (600–300 BC).

Conclusion

Harappa is one of the very few large sites where an entire sequence has been recovered that spans the history of Indus cities, from the Early Harappan village level/pre-urban phase, to the height of Harappan state-level expansion and the Late Harappan, final urban occupations. In our research at the site we have implemented an integrated approach that combines traditional archaeological survey and excavations with high definition analysis, supported by experimental and ethnoarchaeological studies. This research strategy has turned out to be extremely rewarding and is well worth the time and effort necessary to build complex, interlinked data sets. From the minute details of specific crafts to the larger trade patterns of raw materials and finished objects we are coming closer to understanding the role of craft technologies in the origins and character of the ancient city of Harappa, and the larger Indus Valley Civilization. Furthermore, many of the technologies first developed in the Indus cities provided the foundation for later technologies used in South Asia and other regions of the Old World. The long-term results of this research will be a better understanding of how the Indus Valley Civilization has contributed to the development of technologies and urban strategies that have affected the history of South Asia and the world as a whole.

Acknowledgements

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Microstratigraphic traces of site formation processes and human activities

W. Matthews, C. A. I. French, T. Lawrence, D. F. Cutler and M. K. Jones

Abstract

The aim of this paper is to show how micromorphology is able to furnish information with the degree of precision necessary for analysing site formation processes and traces of activities in a variety of settings. Use of large resin-impregnated thin sections allows contextual analysis of taphonomy and depositional relationships between sediments and artefact and bioarchaeological remains. We illustrate this by reference to results from a three-year NERC project which examined depositional sequences in core domestic and ritual contexts in three early urban sites in the Near East in different sociocultural and environmental contexts. We discuss how micromorphology is able to trace different pre-depositional, depositional and post-depositional histories of components, before considering its contribution to detecting spatial and temporal variation in uses of space; enabling identification of single depositional episodes within secondary contexts. Together these capacities are providing richly networked data on human activities and behaviour.

Keywords

Micromorphology; Near East; urban sites; depositional processes; taphonomy; use of space; human activities and behaviour.

Introduction

In a review of formation processes and their identification Schiffer concluded that 'even when multiple lines of evidence are brought into the analysis, the genesis of complex deposits formed by many processes may, in our current state of knowledge remain uncertain' (Schiffer 1983: 680). Part of the difficulty lies in the fact that different lines of evidence are either irreversibly separated or bulked together during routine processes of extraction or sample preparation, such as are employed in many analyses of organic, inorganic or artefactual remains. The principal contribution of micromorphology is that it not only enables simultaneous analysis of diverse sediments and artefactual and

bioarchaeological components, but also provides precise details of their depositional and contextual relationships which are themselves valuable sources of sociocultural and environmental information.

Developments in micromorphology

Micromorphological analysis of intact sequences of deposits in resin-impregnated thin sections was first developed in the study of soils in the 1930s and first applied in archaeology to study of palaeosols in the 1950s. Technological and methodological developments in the 1970s and 1980s have enabled more widespread application of the technique. Manufacture of unsaturated crystic polyester resins has facilitated routine production of mammoth thin sections (Murphy 1986) which, due to their large size at 13.5 × 6.5 cm, enable better correlation between macroscopic and microscopic features and observations. Development of an internationally standardized analytical methodology based on description of morphological attributes of organic and inorganic components (Bullock et al. 1985), rather than classification of soil genesis, has enabled application of micromorphology to a wider range of disciplines including analysis of deposits in archaeological sites and environments (Courty et al. 1989).

Goldberg was one of the first to suggest that 'thin sections could be used to evaluate such actions as trampling and compaction in streets. The resulting fabrics and textures should be different from those of other activity areas such as kitchens, storerooms, Holy Places, and market squares' (1983: 147–8).

Micromorphological studies of occupation sequences and uses of space have since included analysis of deposits within caves (Goldberg 1987; Courty et al. 1991), and settlements (Courty et al. 1989; Weiss et al. 1993; Matthews and Postgate 1994; Courty et al. 1994; Macphail 1994; Macphail and Goldberg 1995). Analysis of plant remains in particular is being developed (Wattez and Courty 1987; Schiegl et al. 1996; Matthews et al. forthcoming), and experimental and ethnoarchaeological research undertaken (Davidson et al. 1992; Goldberg and Whitbread 1993).

Microstratigraphy and its contribution to interpretation of use of space and human behaviour

Ethnoarchaeologists and geoarchaeologists have argued that all component materials in depositional sequences, including sediments, are potentially informative about cultural behaviour and settlement history. In particular, during ethnoarchaeological research in Iran Kramer observed:

> The floor of each area within a house compound is peculiar to that kind of area and therefore diagnostic of primary function . . . it is likely that an excavator could readily distinguish between roofed and unroofed areas, [and] identify stables, storerooms, kitchens and living rooms . . . by evaluating variations in floors.
>
> (1979: 148–9)

Anthropological studies illustrate that space as defined by architectural units is endowed with meaning through practice which is both informed by and therefore representative of sociocultural behaviour and conceptual schemes (Bourdieu 1977; Moore 1986; Wilson 1988). Microstratigraphic analysis within architectural units offers potential for detecting and interpreting the 'maze of spatial conventions whose invisible lines get easily scuffed and trampled by ignorant . . . feet' of anthropologists (Carsten and Hugh-Jones 1995: 4), by enabling high resolution analysis of floors and the often sparse traces of activities on them. Finds within buildings are often few or represent discard/abandonment activities and may have been subject to disturbance (Schiffer 1987). The McKellar hypothesis states that it is the smaller artefactual remains which are 'more likely to become primary refuse' even in areas which are periodically cleaned (Schiffer 1983: 679).

Research design

The principal objective of a three-year NERC research project undertaken by the authors was to develop the application of micromorphology to the study of variation in formation processes and uses of space at sites in different sociocultural and environmental situations. One specific aim was to identify the diverse plant remains which are abundant in thin sections in order to study taphonomy and use of plants. The sites selected lie on a transect through major geobotanical zones in south-west Asia (Fig. 1; Zohary 1973: map 7) where deposits have been subject to less bioturbation than is often present in temperate regions and provide a potentially clearer signal of the imprint of human activities. The well-defined architectural units in early urban settlements of this region provide rigorous contextual controls for scientific analysis of variations in depositional sequences and other archaeological remains, and a basis for establishing sets of characteristic attributes which can be used as a comparative key in studies of other settlements.

The Neolithic settlement at Çatalhöyük in central Turkey is of world importance due to the complexity of its art and architecture, and the richness of its artefactual and bioarchaeological remains during the period of agricultural development, c. 7,000–6,200 BC (Mellaart 1967; Hodder 1996). The site is located on the Konya Plain which is characterized by calcareous Pleistocene lake deposits and alluvial deposits from the surrounding limestone, schist and volcanic mountains (Roberts et al. 1996). The site lies north of the early Holocene Mediterranean woodland climax zone, on the boundary between Xero-Euxinian *Querco Artemisietea anatolica* steppe-forest and central Anatolian dwarf-shrub steppes of *Artemisietea fragrantis anatolica*.

The urban regional centre at Tell Brak, in north-eastern Syria, was occupied from at least the sixth to the second millennium BC (Oates and Oates 1993; Matthews et al. 1994; R. Matthews 1995). It is located in an area of extensive alluvial and colluvial Quaternary silts and sandy silts derived from calcareous mountains in southern Turkey (Courty 1994), and currently lies on the edge of the 200 mm isohyet in Mesopotamian steppe vegetation of *Artimisietea herbae-albae mesopotamica*.

The settlement at Saar on the island of Bahrain was engaged in trade in the Arabian Gulf on routes between Mesopotamia and the Indus c. 2000–1800 BC (Moon et al. 1995; Killick 1997). It is located on a limestone ridge between sand dunes and calcareous silty

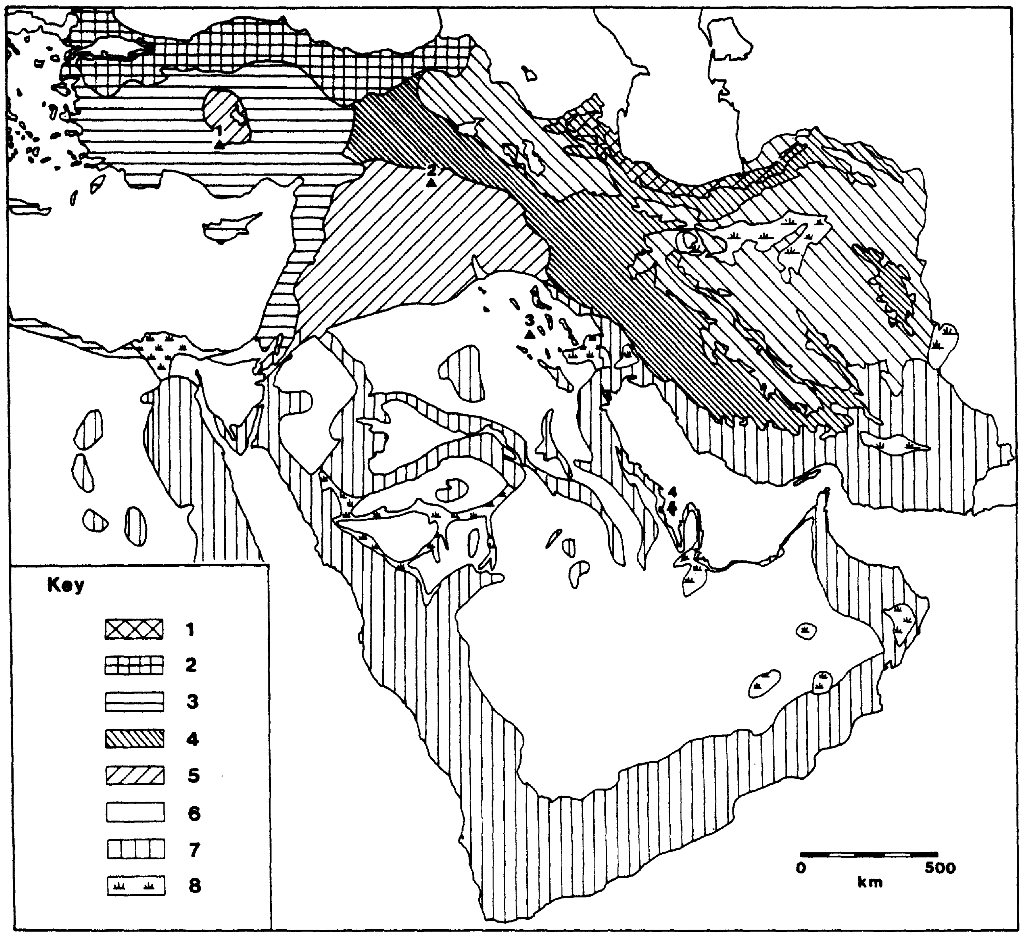


Figure 1 Map showing location of sites studied and major geobotanical zones in south-west Asia (simplified from Zohary 1973: map 7).

Site key

1 Çatalhöyük, central Turkey
2 Tell Brak, NE Syria
3 Abu Salabikh, S Iraq
4 Saar, Bahrain

Geobotanical Key

1 Hyracian and Sub-Hyracian mesic forest
2 Euxinian and Sub-Euxinian mesic deciduous and mixed forest
3 Mediterranean woodland climax
4 Kurdo-Zagrosian and other Iranian steppe-forest climaxes
5 Irano-Turanian steppe and desert vegetation
6 Saharo-Arabian desert vegetation
7 Sudanian and Sub-Sudanian vegetation (Tropical deserts, savanna and forests)
8 Halo- and hydrophytic vegetation

clay in the remnants of an adjacent shallow bay (Doornkamp et al. 1980) in the Sub-Sudanian vegetation zone.

Comparable core domestic and ritual contexts studied at each site include roofed areas adjacent to facilities for food production and cooking, sitting/living, storage, and ritual

activities such as altars; unroofed courtyards, middens and streets, and natural and ethnoarchaeological contexts.

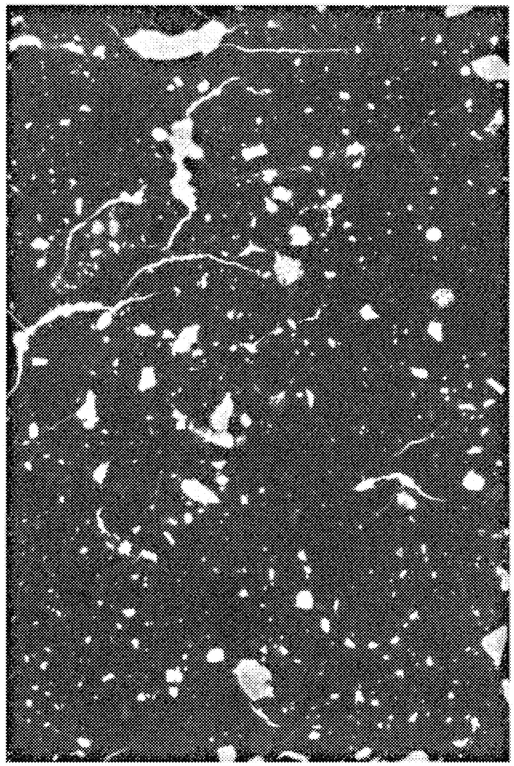
Integrated approaches to analysis of occupation deposits

In order to understand the complex pre-depositional, depositional and post-depositional histories of occupation deposits it is important to adopt research designs which raise these questions during excavation, recording, and sampling, and which enable integration of a range of field and laboratory characterizations, each of which has its own advantages and limitations and potential for different 'readings' of macroscopic, microscopic, chemical and physical attributes (Barham 1995; Canti 1995).

Integrated microstratigraphic and micromorphological analyses can provide links, firstly, between field and microscopic observations at both low and increasingly high magnifications of 40×–600×, in a range of visible plane polarized, cross-polarized, reflected and fluorescent light fields (Courty et al. 1989; W. Matthews 1995), and, secondly, between these and chemical and elemental characteristics when combined with the use of staining techniques and scanning electron microscopy coupled with microprobe analysis (Jenkins 1994). Each field section was photographed, drawn at the scale of 1:5 and recorded; and more than 200 thin section samples were collected, prepared and described following established procedures (Bullock et al. 1985; Murphy 1986; Courty et al. 1989; W. Matthews 1995). Sorting and statistical analysis has been considerably aided by design of a relational database using Microsoft Access with the help of T. Ritchey. Anatomical characters of plant remains were studied at the Jodrell Laboratory Kew by comparison to extensive thin section reference collections and photomicrographic atlases (Matthews et al. forthcoming).

The only difference between observations and interpretations in the field and in thin section is the greater visible resolution provided by microscopic analysis. Micromorphology could be used much more widely by archaeologists. Interpretation of microstratigraphic sequences both in the field and in thin section is based on internal and comparative analysis of the type, frequency, morphology and structural relationships of depositional components and boundaries in each sequence, and their spatial, temporal and sociocultural contexts within settlements. These observations and interpretations are at the same time part of dialectic working hypotheses based on (i) other artefactual and organic and inorganic information from the same context, and (ii) comparisons with sets of information and theories relating to activities and depositional agencies, processes and forms in settlements and environments from other studies in archaeology, ethnoarchaeology, and the natural sciences (Plates 1 and 2).

The principal limitations of micromorphology are that sample sizes are small and the emphasis in analysis is largely on extant visual attributes. The potential use of the technique is best incorporated into well-integrated research programmes. Results from this project are being compared to complementary analyses of larger samples of artefactual and bioarchaeological data from controlled volume wet-sieving and flotation, and pollen and phytolith analyses, for example, and a range of organic and inorganic analyses, although in many cases results are pending. Preparation of thin section samples requires a well-equipped laboratory and a time period of up to six weeks for the resin to harden.



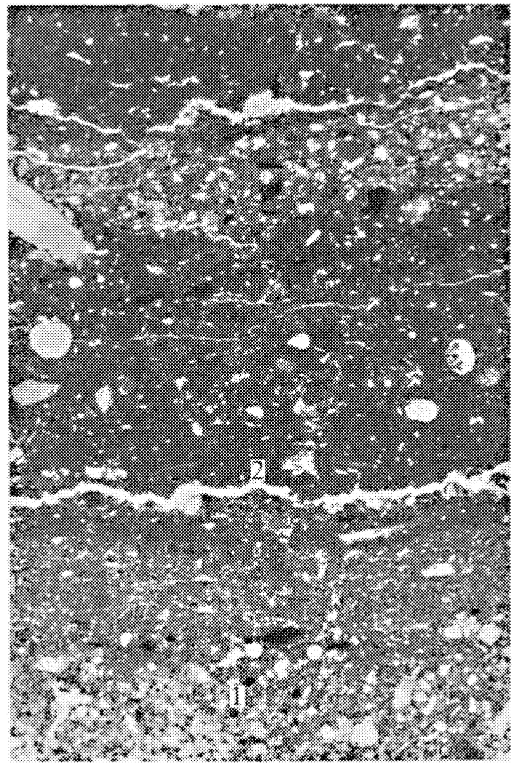


Plate 1 (*left*) Modern sample of Quaternary soft lime deposits which occur within 5 km of Çatalhöyük and closely resemble materials used in Neolithic white wall and floor plasters (Plate 2). These deposits comprise up to 95% pure carbonates of calcium and magnesium, and are used today for plastering floors and walls in surrounding settlements. Sample Çh94.50, plane polarized light (PPL). Frame height = 7.2 mm.

Plate 2 (*right*) Neolithic example of (1) slightly sandy silt loam foundation plaster and (2) fine calcareous silty clay plaster floors which resemble deposits in modern samples of soft lime (Plate 1), in 'Shrine' VIII.25 at Çatalhöyük. The microstructure exhibits some irregular undulating parallel and occasionally perpendicular cracks, suggestive of trampling. Sparse lenses of accumulated deposits are less than 0.2 mm thick, and comprise almost sterile silt (clay) loam with 2% finely fragmented charred flecks. PPL. Frame height = 7.2 mm.

More immediate high resolution analysis of deposits during excavation can be provided by microscopic study in field laboratories of visual and chemical attributes of deposits on acetate peels, in unconsolidated blocks, and loose or in different mounting media.

Tracing site formation processes and pre-depositional, depositional and post-depositional histories of components

Micromorphology enables us to draw together multiple strands of evidence on site formation processes and traces of activities by permitting simultaneous analysis of a diverse range of mineral, bioarchaeological and artefactual remains, and their pre-depositional,

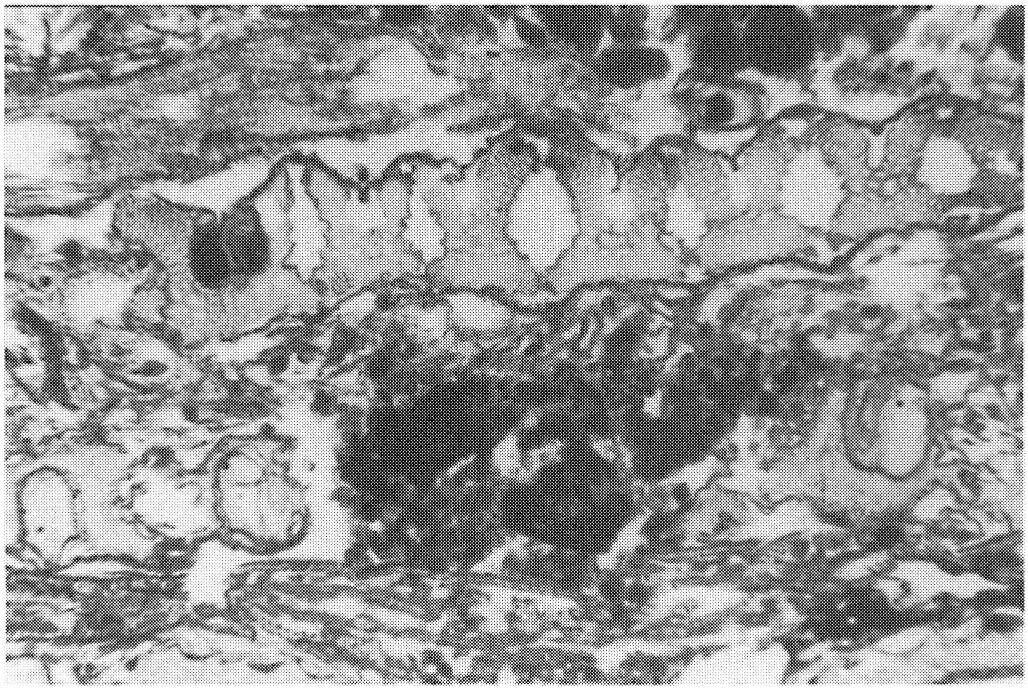


Plate 3 Siliceous and possibly partially desiccated, *Arundo donax* leaf fragments with *in situ* bulliform cells, in an oven, Tell Brak, Syria. Transverse section, PPL. Frame width = 1.04 mm.

depositional and post-depositional histories. Identifiable components include mineral sediments and rock fragments of clay, silt, sand and gravel particle sizes. Bioarchaeological remains include animal and fish bone, shell, coprolites and a diverse range of articulated plant materials, parts and taxa. In thin section it is evident that charred plant remains, on which many analyses of human use of plants are based, only constitute a small and varying percentage of the plants preserved in settlement deposits in semi-arid regions (Matthews et al. forthcoming). Large quantities of plant remains are preserved as fragile articulated siliceous remains or phytoliths (Plate 3; see also Rosen 1992), calcareous ash and, to a lesser extent, desiccated remains, pseudomorphic voids or casts of plants which have since decayed, and pollen. Artefactual remains include fragments of obsidian, flint/chert, grindstone, pottery, bitumen, red ochre, plaster, mudbrick and mortar.

Pre-depositional histories of components

Pre-depositional histories of components can be traced by examination of their internal structure and external morphology. The origin of natural and anthropogenic aggregates can be determined by comparative analysis of, for example, the internal graded bedding of water laid deposits (Plate 4), digested components and microstructure of coprolites, or homogeneously pugged fabrics of building materials. Aggregates in street and courtyard deposits are often subrounded from trampling, and occasionally coated in sediments which differ from the surrounding matrix, suggesting they are in a secondary context.

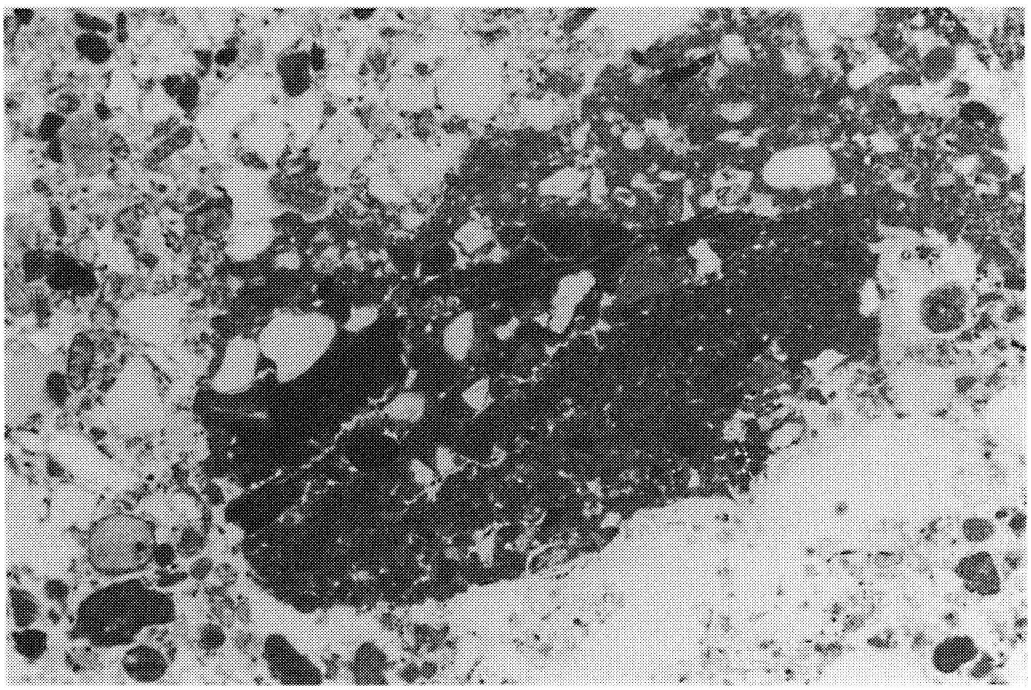


Plate 4 Subrounded aggregates of wind and water-laid deposits in trampled deposits in the courtyard in House 205, Area 237, Saar, Bahrain. PPL. Frame width = 4.4mm.

The general effects of different temperatures and regimes of burning can be detected in many components including aggregates, bone, shell and plants (Courty et al. 1989; Wattez and Courty 1987). We have been able to demonstrate that the sparsity of plant remains retrieved by flotation in the Arabian Gulf is not due to poor preservation as often suggested, but due to widespread use of date palm leaflets and rachis as fuel, which tend to leave little residual carbon when burnt, and are remarkably well preserved in thin section as articulated siliceous and desiccated remains in hearths, and adjacent rake-out (Plate 6).

Depositional agencies and processes

The effects of natural agencies are more pronounced in deposits formed during phases of negative demographic growth or structural abandonment, as also observed in micromorphological studies of Palaeolithic open air sites (Gé et al. 1993) and by Butzer (1982: 90–1). Two major natural horizons were identified in the research project. The first occurs at Tell Brak in the late third millennium BC, and may correspond with a period of environmental stress or instability (Weiss et al. 1993; Matthews 1994), or represent differential abandonment or localized sediment capture. It is represented by extensive thin water-laid crusts in courtyards prior to deliberate infilling of two monumental buildings, a sequence of wind and water-laid deposits associated with collapsed rubble in a lane, extensive reprecipitation of anhydrite (dehydrated gypsum), which was trampled *in situ* during re-use of the lane, and deposition of calcareous spherules (Matthews et al. in prep). The second

horizon occurs at Saar after the final phase of occupation c. 1800 BC, when extensive wind-blown medium and coarse sand infilled buildings and streets to depths of more than one metre.

The only surviving traces of wind- and water-laid deposits in intensively occupied streets and courtyards tend to occur either close to wall faces where deposits have not been extensively trampled or reworked, or as subrounded aggregates in trampled deposits (Plate 4). Many well-sorted wind-laid deposits in thin section clearly comprise sand size aggregates of finer deposits, which would be broken down during routine preparation for particle size analyses and difficult to interpret. Observation and measurement of preserved water-laid crusts and wind-laid deposits is providing information on natural sedimentation rates in a range of contexts.

Anthropogenic agencies and processes of deposition can be detected by analysis of the type, thickness and frequency of floors or surfaces, the impact of activities on those surfaces and the nature of accumulated deposits. Micromorphology is enabling discrimination between passive unaltered zones within floors, reactive zones at the top of floors, and active zones where sediments from floors may be incorporated into overlying deposits (Gé et al. 1993; W. Matthews, 1995).

Although different sediment sources were available in each environment, similar types of materials and techniques were employed in the preparation of floors in corresponding contexts at all of the sites studied (Table 1). Analysis of samples from natural deposits in the environs of each site is enabling identification of probable source materials (Plates 1 and 2).

Incorporation of fine and coarse sediments from floors into overlying occupation deposits appears to vary according to the inherent properties of each type of floor, the presence of any coverings such as mats or loose 'straw', the impact of natural and human agencies, and microenvironment. Impressions and remains of mats/rugs have been identified in thin section often in association with microlenses of compacted silty clay between floor and probable overlying mat/rug. The presence of dislodged aggregates from plaster floors in overlying deposits tends to co-occur with sub-horizontal cracks in reactive zones of floors, particularly in domestic rooms, and almost certainly relates to trampling (Plate 8; Davidson et al. 1992; Gé et al. 1993). Sandy deposits laid as foundation materials and unprepared surfaces tend to become readily mixed with overlying occupation deposits in trampled areas at Saar.

Thin lenses of accumulated occupation deposits on floors are often characterized by moderately dense microstructures with embedded or bridged related distributions and moderately linear orientations and parallel distributions. Many secondary discarded deposits in middens and courtyards, by contrast, are characterized by complex packing void microstructures, intergrain aggregate related distributions, and are unoriented with random component distributions, probably due to disruption of coarse and fine materials during collection and dumping, and separation as they fall to the ground.

Micromorphology is establishing that the concentration, preservation and rates of accumulation of activity residues and deposits vary according to: the nature and quantity of materials used; sociocultural attitudes to and tolerance of accidental and discarded residues; intensity of trampling; sequence of cleaning operations; nature of the substrate; natural agencies; and, microenvironment (Table 2). Measurement of the extant thickness

Table 1 Particle size and fine material of floors in sites from different environmental and sociocultural contexts

Floor type	*Particle size and fine material* *Çatalhöyük*	*Tell Brak*	*Saar*
Fine	White calcareous silty clay soft lime deposits. Mineral fine material	1) White silty clay-silt loam 2) Gypsum. Mineral fine material	Pale brown diatom rich calcareous silty clay. Mineral fine material
Medium	Silt clay loam-sandy silt loam 1) Mineral 2) Organo-mineral fine material	Silt clay loam-sandy silt loam 1) Mineral 2) Organo-mineral fine material	Sandy silt loam-loamy sand Mineral fine material
Coarse	Silt loam-sandy silt loam 1) Mineral 2) Organo-mineral fine material	Silt loam-sandy silt loam 1) Mineral 2) Organo-mineral fine material	Loamy sand with rock fragments Mineral fine fabric
Aggregate hard-core		Mudbrick, burnt aggregates, pot sherds, cobbles. Organo-mineral fine material.	Sand with sparse calcareous rock fragments. Little fine material
Mats/rugs	Impressions. Reed and grass stem and leaf mat remains	Impressions	Impressions. Date palm leaflet, and reed and grass stem and leaf, mats

of depositional units and sequences can provide some indication of relative rates of accumulation (Fig. 5; Matthews and Postgate 1994: fig. 15.9), although thicknesses also vary according to degradation of organic remains, and compaction within settlement mounds.

Post-depositional alterations

In thin section it is possible to identify the effects of a range of natural post-depositional alterations. Reprecipitated salts from evaporation of groundwater and rain in these semi-arid regions are more abundant in unroofed contexts (Table 2), and principally comprise gypsum and occasionally anhydrite. Their formation has resulted in reworking and dis-aggregation of deposit microstructures, and impregnation and cracking of organic materials, including bone, plant remains and organic aggregates/coprolites. Some salts show signs of having been trampled and incorporated into deposits, confirming in these cases their contemporaneity with past occupation. Few examples of translocated fine materials or hypocoatings have been detected in semi-arid settlements, probably due to high surface run-off. Truncation by erosion is more difficult to detect in settlement deposits than in natural deposits, due to the often unsorted particle sizes, heterogeneous composition, and trampled boundaries of occupation sequences.

Post-depositional alterations by biological agencies evident in thin section include bio-turbation from root and insect activity, and indications of organic diagenesis and decay associated with microbial filaments, bacteria, spores, amorphous organic staining, and pseudomorphic voids, particularly of plant remains.

Anthropogenic modification and post-depositional alteration of deposits is part of a continuous cycle of discard, trampling, sweeping, cleaning, and truncation associated with different activities and sociocultural practices. Analysis of known contexts, such as streets for trampling and middens for secondary discard, has enabled identification of clear sets of attributes associated with each of these activities. Trampled deposits are often unori-ented, homogeneously reworked and fragmented. Finely comminuted, subrounded and dusty deposits on floors have probably been swept. Truncation by human actions is diffi-cult to detect, but isolated islands of plaster floor at Çatalhöyük indicate that, in one instance, at least three floors had been removed, a practice documented by ethnoarchae-ological research (Yalman pers. comm.).

Attributes characteristic of domestic and ritual contexts

Thin section analysis is enabling identification of sets of key attributes which are charac-teristic of depositional sequences and uses of space in different sociocultural and environ-mental contexts (Table 2). These general characteristics suggest that although precise sequences of daily activities may vary, and different cross-cultural meanings may be attrib-uted to each context, there are general principles and processes which affect the nature of floors and accumulated occupation deposits in different context types which relate to fundamental physical and sociocultural needs. Although deposits at Saar have a coarser particle size and less fine material than other sites, due to the location of the site in a sandy rather than a silt loam environment, there are many general similarities in the relative

Table 2 Sets of micromorphological attributes characteristic of domestic and ritual activities in different environmental and sociocultural contexts. Attributes specific to individual sites indicated by abbreviated references: (Çh) = Çatalhöyük, (TB) = Tell Brak, (Sr) = Saar, (AbS) = Abu Salabikh

Context	*Prepared or unprepared surfaces*	*Accumulated deposits*	*Post-depositional alterations*
Roofed *Food preparation* Adjacent to grindstone settings	Thick (medium) plasters of sandy silt loam-silt loam	Discrete strong parallel oriented lenses of organo-mineral deposits with 2–5% grindstone fragments <3 mm: Type 1) silt loam with embedded microstructure and 2–10% vegetal voids and 2–20% siliceous Gramineae (TB, AbS) Type 2) sandy loam with intergrain aggregate microstructure and 2% siliceous Gramineae (Sr)	organic staining, bioturbation, salt immediately below some thick layers of plaster
Food cooking Areas adjacent to ovens and hearths	Infrequent (medium + coarse) plasters of sandy silt loam-silt loam. Unprepared surfaces represented by 1) compacted boundaries or 2) a change in deposition	Multiple layers of moderate parallel oriented sandy silt loam-silt loam with organo-mineral fine material + intergrain aggregate related distr. with 10–80% burnt fuel + oven plaster fragments, organic aggregates, bone, flint/obsidian flakes: Type 1) includes charred grain + tubers (Çh, TB) Type 2) date palm phytoliths (Sr)	sub-horizontal cracks in plaster floors, pale yellow salts +/or other salts, bioturbation, organic staining
Storage Small rooms or bins	Thick dense (medium) sandy silt loam-silty clay plaster with added vegetal stabilizers. Occasional gypsum plaster (TB)	Type 1) deposits of pure charred ceral grain with little fine material and 10% packing voids Type 2) unoriented charred seeds and grains randomly scattered throughout structural collapse Type 3) sparse microscopic residues or staining between multiple layers of plaster lining	bioturbation
Reception/clean activities: sitting/food consumption/sleeping	Multiple layers of well prepared (fine + medium) plasters of sandy silt loam-silty clay, often with fine finishing coats (silt loam-silty clay). Impressions of mats/rugs on plasters common	Type 1) thin lenses of finely fragmented charred and siliceous plant remains Type 2) microlenses of sterile silty clay with strong parallel orientation Type 3) sparse microscopic residues	organic staining, horizontal cracks
Ritual Areas associated with ritual features including: altars, symbolic sculptures and wall paintings, or graves	Multiple layers of well prepared (fine + medium) plasters of sandy silt loam-silty clay loam, often with fine finishing coats (silt loam-silty clay). Occasionally painted/pigmented (Çh) Thick foundation layers in front of one altar (TB). Impressions of mats/rugs on plasters common	Type 1) burnt remains on top and around altars and in corner of cella Type 2) water laid silty clay crusts and hypocoatins on top and in front of altars (TB, Sr) Type 3) thin lenses or red ochre grains (in a grave and in a fire-installation at Çh) Type 4) sparse microscopic remains	organic staining, salts, bioturbation

Table 2 Continued

Context	*Prepared or unprepared surfaces*	*Accumulated deposits*	*Post-depositional alterations*
Unroofed			
Courtyards-domestic and streets	Few (medium + coarse) plasters of loamy sand-silt loam. Surfaces of aggregate hard-core common. Unprepared surfaces represented by 1) compacted boundaries or 2) a change in deposition. Many unprepared surfaces have been obliterated by trampling, and reworked into thick homogeneous occupation deposits. Bitumen pathways at AbS	Type 1) thick layers of unoriented deposits with organo-cultural refuse and reworked wind and water laid sediments from trampling Type 2) layers of uncompacted moderately well-preserved organo-cultural deposits from temporary clutter refuse + secondary discard Type 3) undisturbed wind and water laid deposits immediately after abandonment Type 4) dung from tethered/roaming animals	salts, bioturbation wind and water reworked
Courtyards- civic, administrative and ritual	Mudbrick foundation layer with baked brick, lime plaster or fine + medium plaster floors. Few unprepared surfaces	Type 1) trampled mineral rich sediments with some burnt remains and cultural refuse Type 2) thin layer of ash	salts, bioturbation, wind and water reworked
Stables (probably roofed)	Very few prepared surfaces. Unprepared surfaces undulating and interbedded	Interbedded lenses of dung pellet fragments and digested plant remains	organic staining, salts, bioturbation
Middens	Very few prepared surfaces. Unprepared surfaces/boundaries represented by 1) change in deposition or 2) in-situ burning	Type 1) discrete lenses of single depositional episodes Type 2) unoriented massive deposition Type 3) sparse wind and water-laid sediments Type 4) in-situ burning	bioturbation, settling and compaction, organic staining

nature and proportions of components and their depositional arrangements in floors and occupation deposits in corresponding context types at other sites, which suggest that it is the dynamics of human activities and influences of microenvironment within the built environment which are perhaps often more significant than the nature of the sediments into which agencies and processes are imprinted.

In roofed areas, many contexts have plastered surfaces. Areas used for sitting/sleeping/clean/ritual activities tend to have multiple layers of well-plastered floors. Storage and occasionally food preparation areas have thick layers of plaster, whereas fewer plaster floors tend to occur adjacent to ovens. In unroofed domestic areas, stables have no prepared surfaces, and streets and courtyards have periodic layers of coarse aggregate hard core or sand. By contrast, unroofed areas in monumental buildings tend to have well-prepared mudbrick foundations and baked brick, lime plaster, or plastered surfaces. Variation in frequency and quality of floors is also suggesting differential access to source materials and perhaps socio-economic status (Kramer 1979: 148).

The nature of accumulated deposits furnishes a second independent set of attributes for characterizing sequences and contexts. In sitting/sleeping/clean areas, accumulated deposits are often thin and sparse, and tend to include only microlenses of silt below mat impressions, or thin layers of hearth rake-out for example. In areas with ritual features, deposits are more varied and include burnt remains or silty clay crusts on top of and around altars. In food storage areas the presence and distribution of stored remains varies from few traces to thick layers of charred grain for example, depending upon the nature of abandonment or destruction. Food preparation areas adjacent to grindstones frequently include grindstone fragments and pseudomorphic voids of plant remains which have since decayed. Areas with ovens often have a rich variety of organic and inorganic deposits which tend to include cereal remains and tubers, bone, oven plaster fragments, and flint flakes for example. Many courtyard and street deposits comprise thick layers of unoriented organo-cultural refuse, subrounded aggregates of wind and water-laid aggregates and often animal dung.

Spatial variation in microstratigraphic sequences and activity areas within domestic houses at Saar in Bahrain

We have identified changes in microstratigraphic sequences within the space of one to two metres which have enabled us to trace the extent of different activity areas and their relationships in two domestic houses at Saar in Bahrain during excavation in one-metre grid squares (Fig. 2).

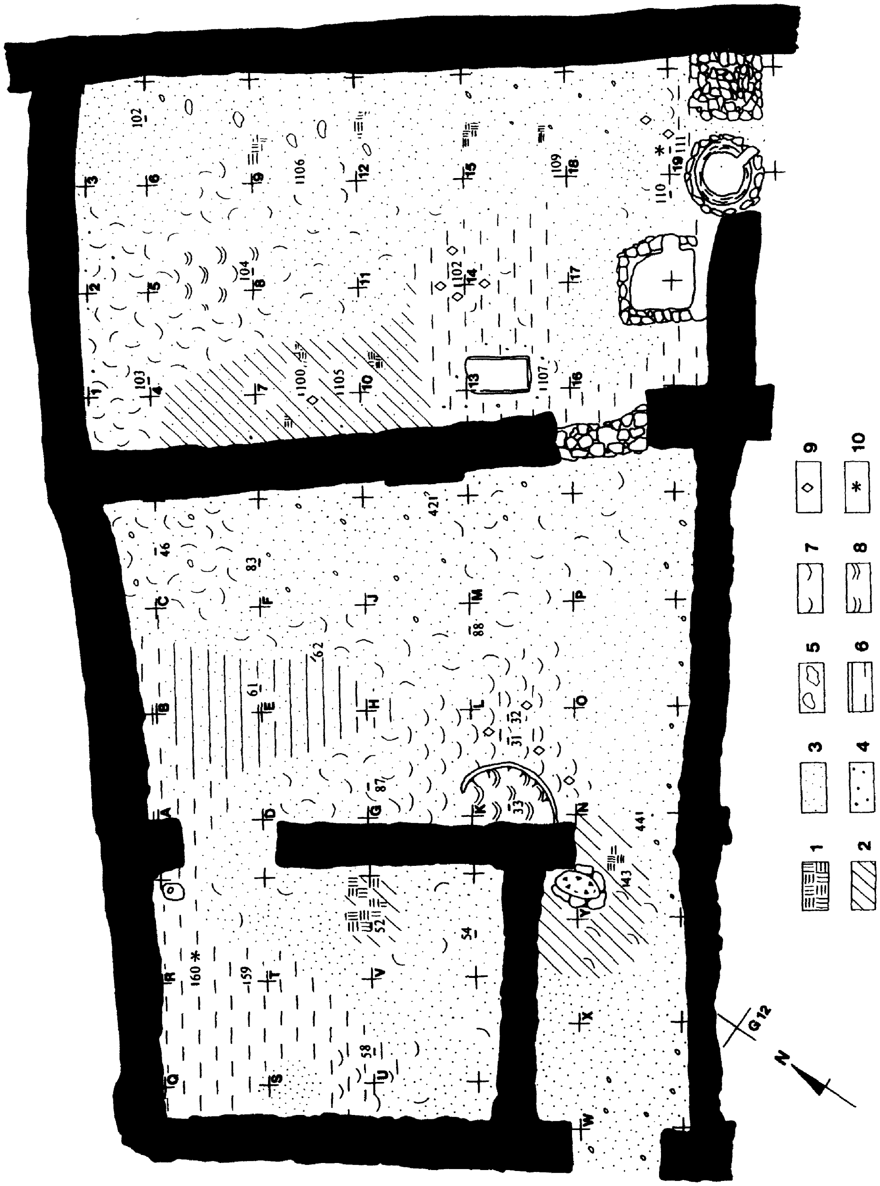


Figure 2 Plan of House 205 illustrating location of grid squares and thin section samples, and the general spatial variation in microstratigraphic sequences at Saar in Bahrain, c. 1800 BC.

Key 1 clay 3 sand 5 rocks 7 burnt plant remains 9 salts
2 silt 4 gravel 6 plaster 8 *in situ* burning 10 organic aggregates/coprolites

Parallel oriented symbols represent parallel oriented deposits, unoriented symbols represent unoriented deposits.

Buildings 205 and 207 are typical of the two- and three-roomed structures at Saar. Both have an L-shaped entrance way and larger area which was probably lightly roofed with date palm fronds, and a small connecting room which was probably roofed with mud plaster (Killick 1997). House 205 has a walled back area with lenses of *in situ* and trampled wind- and water-laid deposits which suggest it was unroofed (Plate 4). Within each one-metre grid square all section faces were drawn at scale 1:5 and recorded, and depositional

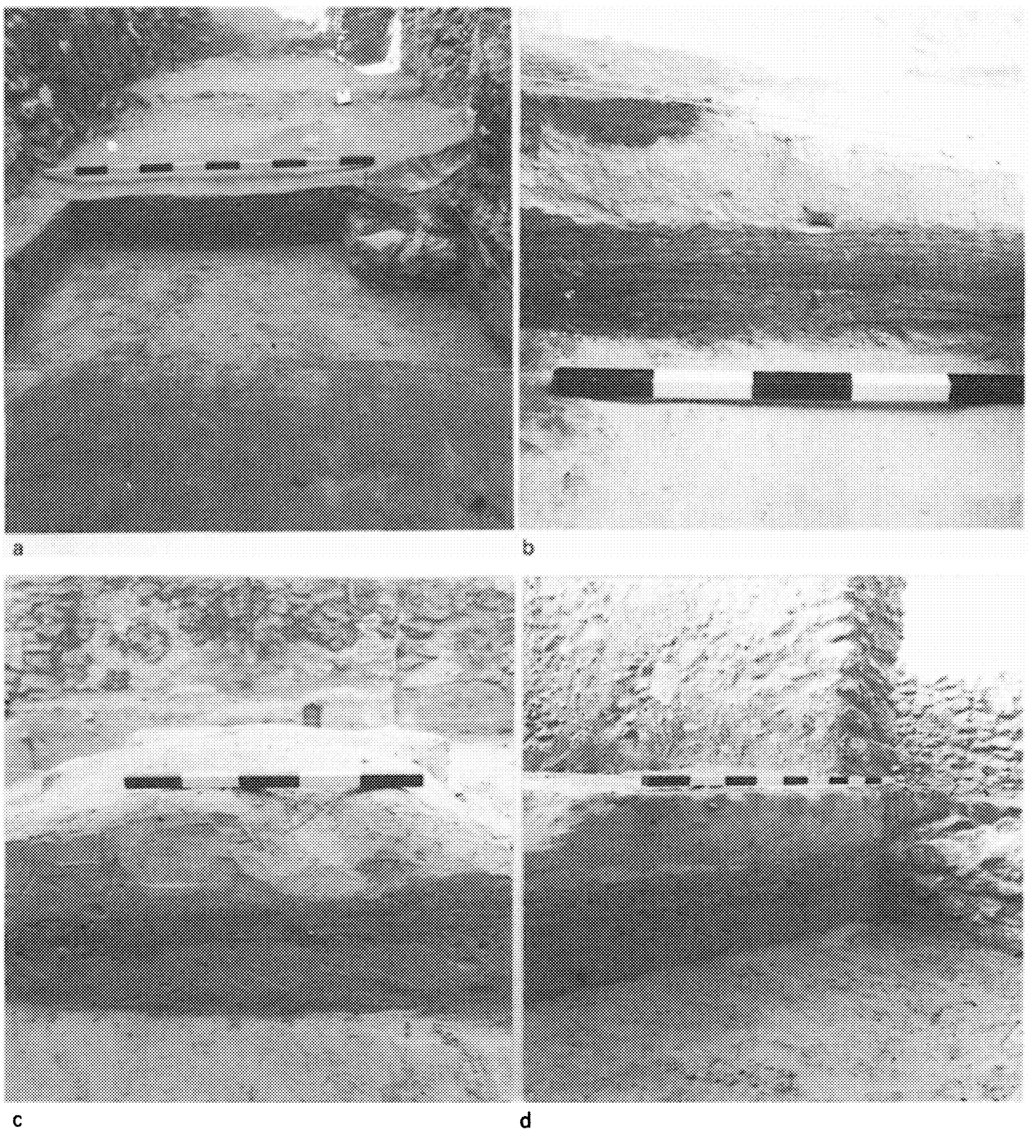


Plate 5 Spatial variation in microstratigraphic sequences in House 205 Area 236 within distances of one to two meters: a) lenses of water splashed deposits in front of the plaster basin in the entrance; b) lenses of date palm ash, salt and fish bone and scales in front of the hearth; c) heavily trampled deposits in the centre of the room; d) fine plaster floors in front of the entrance to the plastered internal room. Scale = 50 cm.

layers planned and wet-sieved and floated in order to study concentration and fragmentation of artefacts and bioarchaeological remains. Samples for thin section and organic and inorganic analysis were collected at one to two metre intervals in order to study observable changes in deposit in the field and features such as hearths or basins.

Spatial variations in microstratigraphic sequences are illustrated in Plate 5 and traced and characterized in Figures 2–5. Integration with thin section analysis has established that in L-shaped areas unoriented trampled deposits with heterogeneous aggregates occur in entrances. Thin layers of water-splashed deposits and sand occur in front of plaster basins. Lenses of date palm ash, fish bone, fish scales, salts and sand accumulated in front of hearths (Plate 6). A very thick homogeneous unit of sandy substrate mixed with finely fragmented debris had been heavily trampled in the central area on major routeways. Discarded ash and bone and eroded mortar from the adjacent wall accumulated in the north-eastern corner of Building 205.

Small internal rooms in both houses have fine plaster floors which have been partially dislodged and fragmented by trampling during accumulation of sandy silt loam layers with some anthropogenic debris.

The back courtyard in Building 205 has a number of spatially separate microstratigraphic sequences which suggest it was used for a range of activities, including grinding, food processing, low temperature burning and dumping of refuse and possibly tethering, feeding and watering of a herbivore. Coarse wind-laid sands accumulated in the eroded north-eastern corner.

Plate 6 Date palm leaflets, burnt aggregates, salts and fish bone and scales in front of the hearth, House 205, Area 236, Saar, Bahrain, PPL. Frame height = 1.3 mm.

Floors	Occupation deposits	Wet-sieving data	Adjacent feature	Location	Interpretation
fine silty clay plaster	*sparse water-laid crusts*			L-shaped area: entrance to small room	clean area in entrance to sitting and sleeping area
fine silty clay plaster *?mat impressions*	*sparse date palm ash sparse 'reed' and grass*	highest concentration of pottery (in corners of room)	stone bench	small room	sitting and sleeping area
gypsum plaster	*sandy loam, sparse ash water-laid crusts*	lowest concentration of bone lowest concentration of pottery	plastered 'table'	L-shaped area: corner	?food preparation
occasional thin plaster lenses of sand	thin lenses of fish bone and scales *moderate parallel oriented date palm ash, salts*	highest concentration of bone high concentration of pottery highest concentration of shell highest concentration of burnt aggregates high concentration of copper	hearth	L-shaped area: edge	food cooking and preparation and fuel rake out
lenses of sand	*lenses of water splashed deposits with sparse ash*	highest concentration of flint	plaster basin	L-shaped area: entrance	washing upon entrance to house from street
thick sandy packing	fish bone including tails *unoriented/uncompacted date palm ash, fish bone, mortar*	largest fragments of bone		L-shaped area: corner	temporary refuse area
	thick homogeneous layer *unoriented sandy loam with sparse datepalm ash and fish bone*	smallest fragments of bone small fragments of shell		L-shaped area: central area	heavily trampled central route way within the house

Floors	Occupation deposits	Wet-sieving data	Adjacent feature	Location	Interpretation
thick fine plaster	gritty *sand, rock fragments salts, fish bone, Gramineae*	moderately high concentrations of bone	grindstone setting	back yard: edge near entrance to L-shaped area	grinding ?Gramineae and ?fish
	ashy *sandy ash with organic aggregates, salts, bone and water laid crusts*			backyard: centre	?food processing in area near to grindstone setting
thick sandy packing	ashy sand *herbivore dung, grasses salts, water-laid silt*		plaster basins	back yard: corner	?tethering, feeding and watering of herbivore(s)
	dark ash parallel oriented *charred date palm, bone and pot fragments*	highest concentration of pottery highest concentration of shell		backyard: central edge	in situ low temperature burning
	ashy sand, gritty *unoriented loamy sand and ash 2-5% bone, unoriented*	moderately high concentration of bone highest concentration of copper fragments		backyard: corner	temporary discard of domestic refuse
	sand and rocks *lenses of wind and water laid deposits*	lowest concentrations of bone		backyard: edge	more sterile area with eroded wall materials ?possibly storage of large bulky items against wall/ hanging of nets etc.
	sand *coarse sterile wind blown sand*			backyard: corner	eroded corner of yard

Key
Field observations
Micromorphological observations

Figure 3a–b Cladistic diagram of key microstratigraphic, micromorphological and wet-sieving attributes diagnostic of different uses of space in roofed and unroofed areas in Houses 205 and 207 at Saar in Bahrain.

These variations in sequences correspond closely with results from analysis of wet-sieving data and finds (Figs 3 and 4). The most fragmented bone and shell occurs in the centre of each area where deposits are heavily trampled. The least fragmented bone and shell occurs in corners used for temporary refuse. The highest concentrations of metal fragments occur

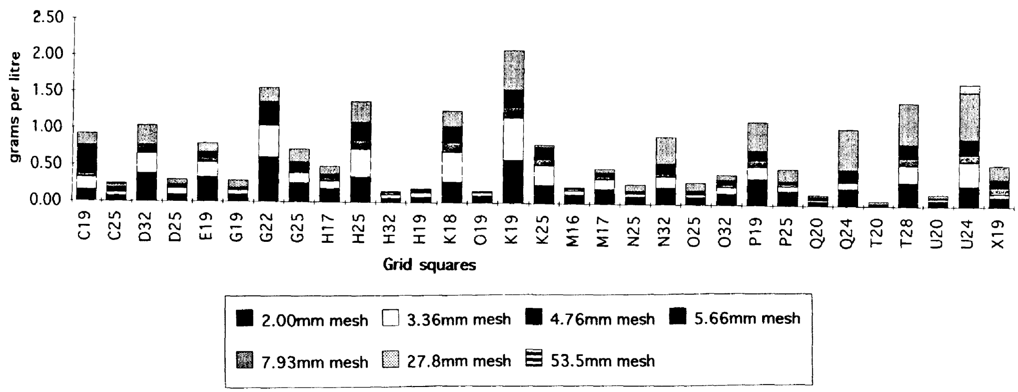


Figure 4 Selected examples of variation in concentrations and degrees of fragmentation of bone in grams per litre, in House 205 Areas 235 and 236 at Saar.

around the hearths. The largest fragments and highest concentrations of pottery occur in the corners of internal rooms. The highest concentrations of flint occur in entrances.

These results suggest that microstratigraphic sequences do vary according to human activities and behaviour and microenvironment even within confined areas, providing the archaeologist with sensitive *in situ* indicators of past use of space and conditions within the built environment.

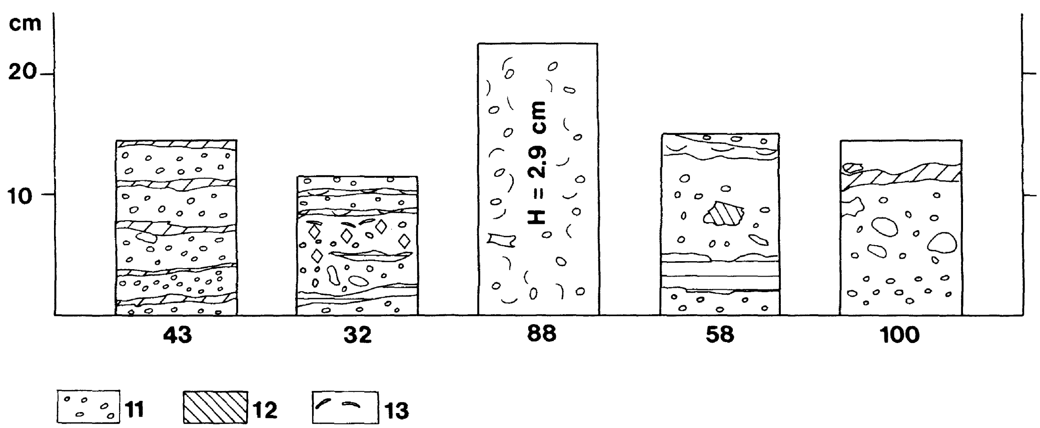


Figure 5 Microstratigraphic columns illustrating variation in the type, thickness and frequency of floors and occupation deposits in House 205 at Saar within distances of one to two metres. Schematic field of view within columns is magnified, column height represents 2.9 cm of deposit.

Thin section no.	Location	Key to symbols (same as Figure 2)
43	L-shaped area, entrance next to basin	11 sand
32	L-shaped area, in front of hearth	12 pottery fragment
88	L-shaped area, central routeway	13 fish bone fragments
58	Small room	
100	Back yard	

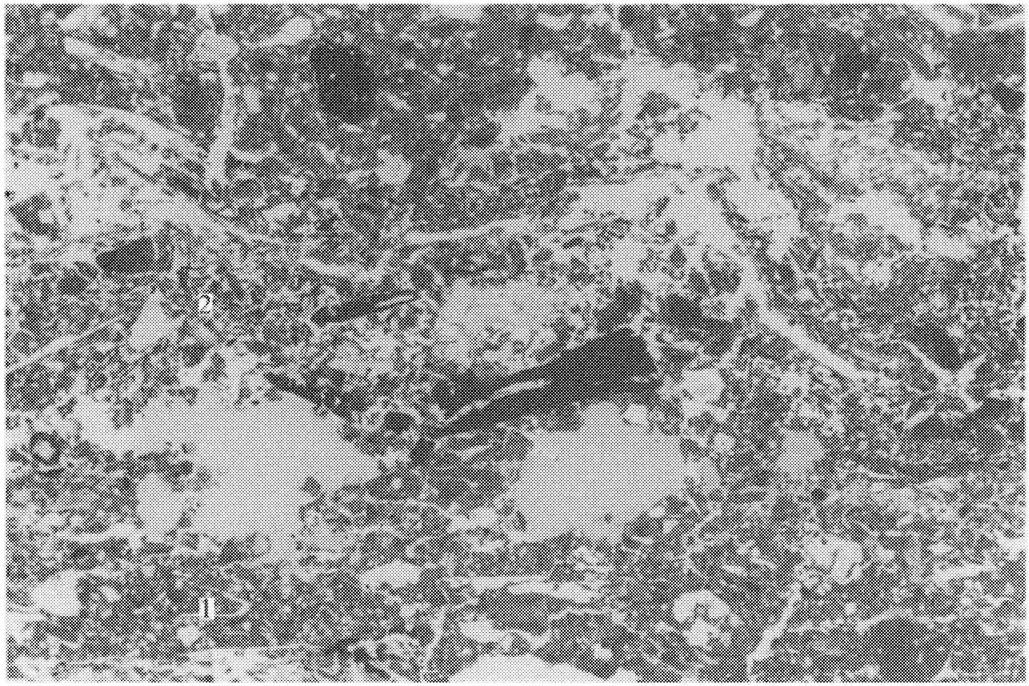


Plate 7 Sequence characteristic of domestic food preparation and cooking activities represented by (1) thick sandy silt loam plaster floor with reprecipitated salt aggregates, and sub-horizontal cracks probably from trampling, (2) accumulated deposits which include dislodged aggregates from plaster floor, charred wood, siliceous and charred grasses and reeds including a cereal-like husk fragment, bone and burnt aggregates of oven plaster. Çatalhöyük, Level VI. PPL. Frame width = 7.2

Temporal variation in microstratigraphic sequences

Analysis of microstratigraphic sequences through entire building phases is enabling study of uses of space and behaviour during the birth, life and death of the building and its occupants, which may not be represented in the architecture. We have observed consistent repetitions in sequences of floors and occupation deposits which suggest continuity and/or cyclicity in human behaviour and sociocultural practices as evident in Plate 5 and Figure 5.

At Çatalhöyük we identified a change in one microstratigraphic sequence which suggests the use of at least an area of a building in Level VI/V may have changed from a domestic residence to an ancestral shrine, after human burial (Matthews et al. 1996: 317–20). Analysis in the field suggested there was a change in the use of space from domestic activities attested by relatively thick plaster floors and burnt trampled occupation deposits associated with a plastered emplacement perhaps for a pot, to cleaner or perhaps ritual activities attested by a sequence of fine white and orange plaster floors which were associated with a collapsed cattle jaw and horn cores, and moulded plastered sculptures on the last floor. This marked change in microstratigraphy coincided with the digging of a large human grave which was sealed by the later sequence of cleaner floors.

In thin section, the thick plaster floors in the initial sequence have sub-horizontal cracks from exposure to heavy trampling, and are impregnated with salts (Plate 7).

Overlying deposits are comparatively thick, at 2–3 cm, and include fragments of oven plaster, charred cereal-like husk, siliceous grasses, ash and bone. The later thin plaster floors often had a finishing coat of white plaster and were kept cleaner. Accumulated deposits are less than 120–720 μm thick and include fibrous, possibly digested plant remains, which strongly resemble a layer of small dung pellets on the latest floor within the building. Organic residue analysis of any surviving traces of coprostanols and bile acids (Evershed and Bethell in press) may aid determination of whether the dung is from (perhaps) a large rat or small sheep/goat, with potentially quite different interpretations.

Two lenses of red ochre which perhaps relate to ritual activities were detected in the top of a small hole in the grave in thin section. These lenses of ochre are less than 120–360 μm thick and are separated by a layer of unoriented wall plaster fragments, 360 μm thick, which may have been dislodged by modification or erection of fixtures and fittings within the room. The hole was subsequently sealed by a thick layer of white plaster.

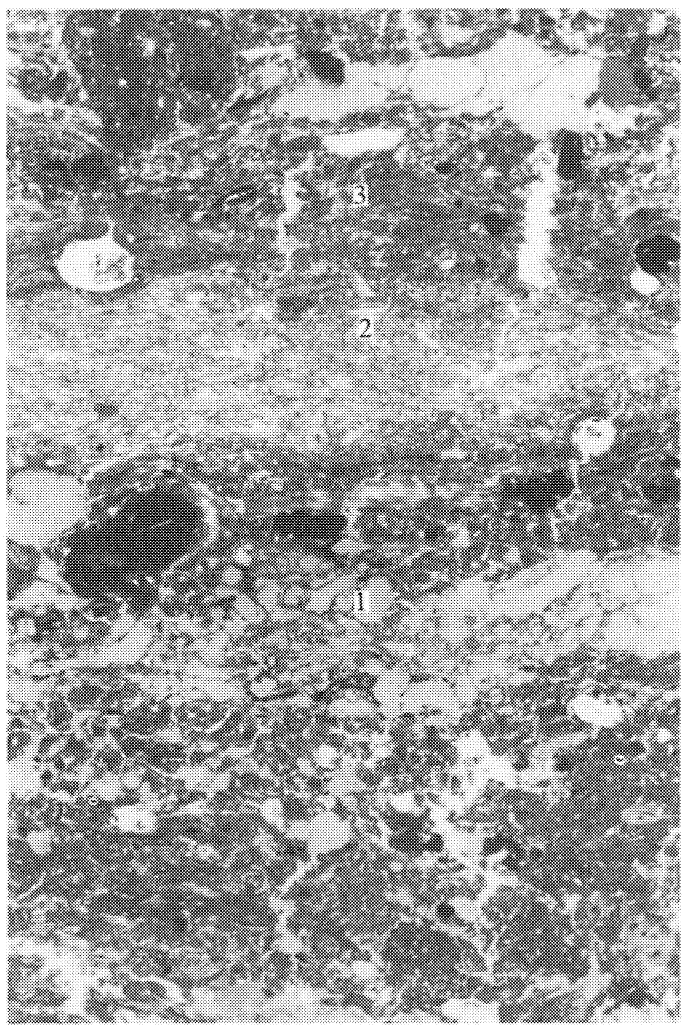


Plate 8 Interbedded layers of dung rich deposits with lenses of (1) salt aggregates, (2) dung pellet fragments and (3) orange organic staining in Neolithic stable deposits. Dung pellet includes parenchymatous tissue from storage organs such as tubers, and a wide range of siliceous grass and 'reed' epidermises. Çatalhöyük. PPL. Frame height = 3.3 mm.

Traces of animals

A range of uncharred herbivore dung has been identified in fire-installations, courtyards and streets at all of the sites studied. Micromorphology has enabled detection of new evidence to suggest that animals were kept in stables within the Neolithic settlement at Çatalhöyük. In thin section, interbedded lenses of orange and white sediments proved to be largely organic in origin, and comprise layers of trampled uncharred dung pellets, organic staining and salts (Plate 8). The dung pellets include siliceous plant remains from a diet of digested tubers and grass stems and leaves, and neo-formed spherulites, 5–20 μm in diameter, which may have formed in the gut of animals during digestion (Canti 1997). This depositional sequence resembles modern samples from a winter stable for sheep and goats from a village on the Konya Plain, both macroscopically and in thin section (Anderson 1995; Matthews et al. 1996). These results have important implications for studies of human animal relationships during the development of agriculture and are being compared to interdisciplinary analysis of zooarchaeological remains.

Microscopic attributes are being compared to organic and inorganic chemical characterizations. The Çatalhöyük stable deposits yielded comparatively high phosphate values, at more than 12,000 parts per million, in preliminary test analyses conducted by Dr D. A. Jenkins and Dr A. Owen. By contrast, mudbricks and alluvial sediments yielded predictably low values at 200–300 ppm. Deposits in rooms varied from 1,000–5,000 ppm, and middens at 10,000 ppm. Distributions of elements, including phosphate, are being mapped using SEM and EDXRA on resin-impregnated slices of deposits.

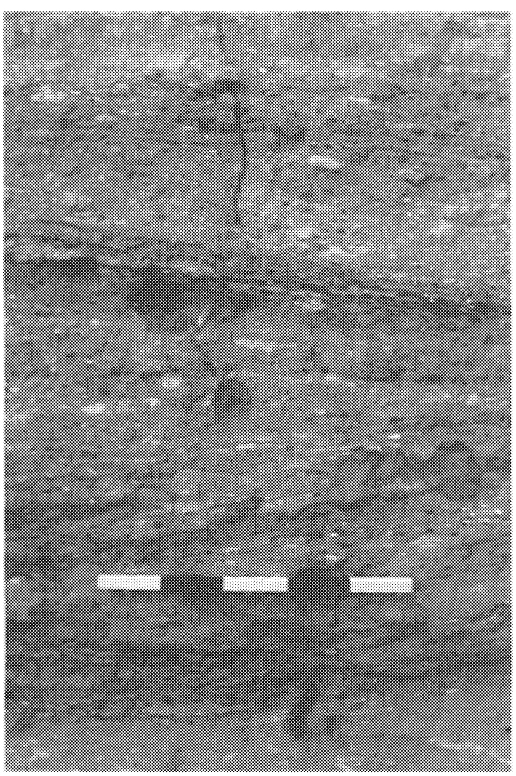


Plate 9 Microstratigraphic sequence of midden deposits at Çatalhöyük, Mellaart Area, Level XI, illustrating multiple layers of compound lenses. Scale = 50 cm.

Identification of single depositional events and individual actions

Micromorphology is enabling detection of single depositional episodes within secondary discard contexts such as middens, pits, courtyards and streets, and identification of the precise contextual relationships between the rich artefactual remains and bioarchaeological remains in these sequences (Plates 9–10). This information is critical to interpretation of palaeoecology and activities conducted within settlements, given the sparsity of finds on many floors.

Single depositional episodes in middens at Çatalhöyük (Matthews et al. 1996) are often less than 0.5 mm–5 cm thick and include burnt oven plaster aggregates and cereal grains probably from a cooking or parching accident; fragments of obsidian flakes and bone associated with subrounded floor plaster fragments, probably from floor sweepings (Plate 10); obsidian flakes associated with tapered slivers of wood, perhaps from wood working and layers rich in organic staining, digested bone, hackberry fruit stones, and phytoliths, which resemble omnivore coprolites from pig, dog or humans, but await results from GC/MS analysis by Dr R. P. Evershed, University of Bristol.

Identification of single depositional events such as a lens of red ochre in burnt fuel in a hearth at Çatalhöyük may enable us to see a shift in the associations and meanings of different spaces, which, as Bordieu observed in modern societies, can vary according to whether a hearth is being used for a domestic meal or a formal feast, for example (1977).

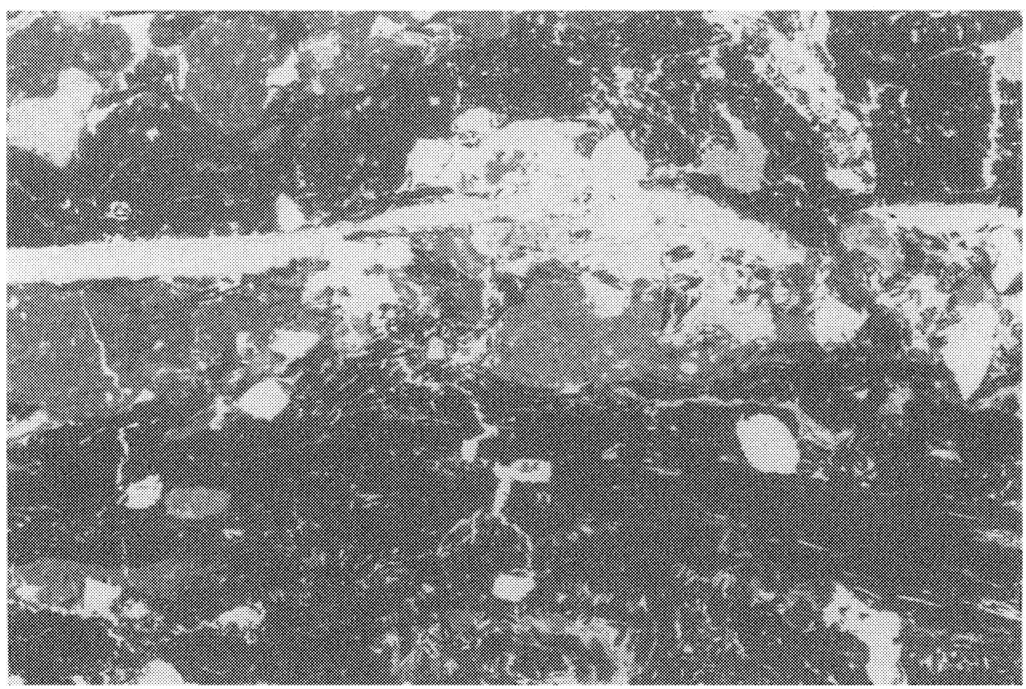


Plate 10 Single depositional episode of floor sweepings within compound midden layers illustrated in Plate 9. This lens includes obsidian flakes, fragments of bone and subrounded aggregates of plaster. PPL. Frame width = 7.2 mm.

These discrete lenses perhaps allow us to come close to attaining the required degrees of precision for tracing remains of individual actions or sets of activities which are central to current methodological and theoretical objectives in archaeology.

Conclusions

Micromorphology enables conjoining of multiple threads of information on the complex genesis of deposits by permitting simultaneous high resolution analysis of diverse mineral, bioarchaeological and artefactual components and their precise depositional and contextual relationships. Micromorphology is bringing into resolution depositional units which are not retrievable by routine excavation, but which clearly relate to discrete depositional episodes and are furnishing important information on the range and sequence of activities within settlements.

Integration of microstratigraphic and micromorphological analyses into multidisciplinary research programmes is enabling tracing of spatial variation in activities and microenvironment within the space of one to two metres, and temporal changes, independent of architectural analyses. We have detected general similarities in the character of floors and occupation deposits in corresponding contexts in different settlements of diverse sociocultural and environmental contexts. In particular, micromorphology is enabling identification and quantification of diverse plant remains and dung, which are not recovered during routine flotation procedures, and are abundant in settlement deposits.

Targeted excavation and integrated sampling strategies can be applied to research programmes in which extensive settlement plans have been mapped using geophysical techniques and extensive surface scraping and planning, given increasing costs of full-scale excavation. We were able to recover considerable information on the nature of a large domestic house with thirteen rooms during selective excavation and integrated sampling of microstratigraphic sequences in the 5G65 House at Abu Salabikh in southern Iraq, *c.* 2,500 BC (Matthews and Postgate 1994).

Future multidisciplinary ethnoarchaeological and experimental research is required in order to develop analytical models and theoretical frameworks for furthering our understanding of the specific relationships between contextual and temporal variation in human activities and natural agencies, and associated depositional sequences within built environments, similar to long-term research at Overton Down (Bell et al. 1995). Thin sections and adjacent resin-impregnated slices offer opportunities for multiple readings of deposits depending on the expertise and interest of the researchers involved, and provide permanent reference collections for analysis as techniques, questions and theoretical frameworks vary and improve.

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